Medical Library

Vol. 23, No. 2 April, 1931

PARASITOLOGY

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CAMBRIDGE UNIVERSITY PRESS

LONDON: FETTER LANE, E.C. 4

ALSO

H. K. LEWIS AND CO., LTD., 136, GOWER STREET, LONDON, W.C.1

CHICAGO: THE UNIVERSITY OF CHICAGO PRESS
(AGENT FOR THE UNITED STATES)

BOMBAY, CALCUTTA, MADRAS: MACMILLAN & CO., LTD.

TOKYO: MARUZEN COMPANY, LTD.

Eighteen Shillings and Sixpence net

Issued 11 *May*, 1931.

PRINTED IN GREAT BRITAIN

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VOLUME XXIII APRIL, 1931 No. 2

THE MORPHOLOGY AND METHOD OF DIVISION OF *TRICHOMONAS*.

BY ANN BISHOP, PH.D., M.SC.,
Beit Memorial Research Fellow.

From the Molteno Institute, Cambridge.

(With Plates VI and VII including 60 Figures.)

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WHILST I was working with Mr Clifford Dobell, F.R.S., we kept cultures of *Trichomonas hominis*, and of strains of *Trichomonas* sp. from *Macacus* monkeys. As there was an abundance of material containing stages of division of these strains at my disposal I began to study the process in detail. If the flagellate is studied directly in faeces the number of individuals found undergoing division is small and the working out of the sequence of changes is very laborious; but if the study is made upon *cultures* of the flagellate the wealth of material makes the work easier.

Part of the following piece of work was done at the National Institute for Medical Research. I should like to record my indebtedness to the Medical Research Council for the grant which made my period of work at their Institute possible. The study of *T. hominis* and the strains from Macaques was completed, and the whole work upon the cultivation and methods of division of *T. batrachorum* was done at the Molteno Institute after I was elected to a Beit Fellowship.

I have had advice and help from Mr Dobell throughout this study and he has kindly read and criticised this paper for me. I am deeply grateful to him for his kindness.

I. Material and methods.

The study of the division processes recorded here has been made upon cultures of *Trichomonas* from man, *Macacus nemestrinus*, *Rana temporaria* and *Bufo vulgaris*. The strain of *Trichomonas hominis* (F.T. strain) was isolated by Mr Dobell (1925) on August 25th, 1925, and cultivated by him, and later by myself, upon inspissated horse-serum slopes covered with egg-white diluted (1 : 8) with Ringer's fluid (Dobell and Laidlaw, 1926). The strain from *Macacus nemestrinus* was isolated (*post mortem*) by Mr Dobell (1928) on August 3rd, 1927, and cultivated by us upon coagulated whole-egg slopes covered with inactivated horse-serum in Ringer's fluid (1 : 8). Later this strain (N.T. strain) was fed by Mr Dobell (*Ann. Report Medical Research Council*, 1929–30) to a *M. rhesus*, which had never been infected with *Trichomonas*, and recovered, in the egg culture medium, from its faeces. A sub-culture of this recovered strain (R.T. strain) was given to me by Mr Dobell and I continued to cultivate it for the purpose of this work. This strain from *M. nemestrinus* was studied before and after its passage through *M. rhesus* and no difference was found in it. It, and the F.T. strain, are identical morphologically and in origin with the N.T. and F.T. strains used in my experiments upon the action of hydrochloric acid (Bishop, 1930), though the R.T. strain differs from the N.T. strain in its experimental history.

Whilst working, during the last session, upon the cultivation of the parasites of the common English frog and toad I have isolated repeatedly strains of *Trichomonas batrachorum*. This *Trichomonas* produces excellent cultures when grown at 15°–20° C. upon a horse-serum slope covered with Ringer egg-white (see above) or upon a horse-serum slope covered with one part inactivated horse-serum and nine parts 0·5 per cent. salt solution. This liquid medium (using human in place of horse-serum) had been used successfully in the cultivation of *Entamoeba ranarum* by Barret and Smith (1926). *T. batrachorum* grew in this diluted serum alone, or in horse-serum diluted in Ringer, but the cultures were never as thick as when an inspissated slope was used as a basis. It was found impossible to *start* cultures in these wholly-liquid media as *Blastocystis* flourishes in them, particularly in Barret and Smith's medium, and is more difficult to eradicate from a wholly liquid than from a part-liquid part-solid medium. Egg slopes covered with Ringer did not give good cultures of this species.

The frogs came from districts near Cambridge, but whilst some of the toads were local ones others came from near Exeter. The frog or toad was killed, the abdominal surface carefully cleansed with alcohol, and the skin cut through longitudinally. The muscular body wall was dissected away, using fresh, sterile instruments, and the large intestine exposed. It was ligatured at both ends and removed into a sterile dish, and parts of its contents inoculated into tubes of medium. From the remaining part preparations were made for examination. For studying the division of these strains smears from the cultures were made

upon coverglasses. A number of fixatives was used, but those giving the best results were Bouin's fluid with acetic acid, used cold, and Schaudinn's fluid with 2–5 per cent. glacial acetic acid, used either cold or at 37° C. Bouin's fluid, modified by replacing the acetic acid by citric acid, was tried, but in my experience did not give as good results as the original formula. Sublimate-formol, which has given me excellent results with amoebae, gave unsatisfactory results with *Trichomonas*. I had no success in using the trichloracetic acid method so warmly advocated by Grassé (1926) for the fixation of these flagellates. The animals appeared distorted and the nuclei abnormal, though I followed his instructions absolutely. As Dobell and O'Connor (1921) and Wenyon (1926) point out *T. hominis* is exceedingly difficult to fix and stain successfully, and though the most rigorous care was taken many preparations were useless through shrinkage or imperfect staining. All the preparations were stained with aqueous iron haematoxylin, the mordant and stain both being used for twenty-four hours.

In the strains from man and *M. nemestrinus*, both grown at 37° C., the greatest number of individuals undergoing division were found in cultures from 24 to 48 hours old. Films were therefore usually made at this time. As *T. batrachorum* grew at room temperature, growth was found to be slower and the largest number of individuals dividing usually occurred on the fourth and fifth day. Whereas the R.T. and F.T. strains were sub-cultivated on the fifth and seventh day *T. batrachorum* needed sub-cultivating only at 10 to 12 day intervals.

II. OBSERVATIONS UPON THE CULTIVATION OF *T. BATRACHORUM*.

T. batrachorum is a very common parasite of the large intestine of *Rana temporaria* and *Bufo vulgaris*. In hosts where these flagellates are present in such small numbers that they escape detection in the direct microscopic examination of the contents of the large intestine they often appear in large numbers in the primary cultures made from it. During the past year I have examined the contents of the large intestine and made cultures from it of twenty-one frogs and twenty toads. Two frogs and two toads were negative for *Trichomonas* both in the direct examination and in the examination of cultures and their sub-cultures.

In attempting to isolate a "pure strain" of *T. batrachorum* (*i.e.* a strain of this species free from other protozoa and from *Blastocystis*—the cultures always contain a growth of mixed bacteria) several difficulties were encountered. *Blastocystis* was present in the large intestine of almost every frog or toad examined. If the tubes in which the primary cultures are to be made are first inoculated with a little solid, sterile rice-starch and with *Bacillus I* (an organism isolated by Dobell and Laidlaw, 1926), the tubes incubated to obtain a good growth and then allowed to cool, the medium is very unfavourable to the growth of *Blastocystis* but proves excellent for *T. batrachorum*. A few sub-

cultures made in this medium kill off the *Blastocystis* of the frog as surely as they do the strains from man or monkey.

As in man or monkey starch-fermenting organisms are often present in the large intestine of frogs and toads. These render the medium very acid and the trichomonads die within a few hours. In most cases where they appeared these "starch-splitters" were killed, without harming the trichomonads, by the addition of dilute flavine (Dobell and Laidlaw, 1926) for several sub-cultivations. Occasionally, however, a strength of flavine toxic to the trichomonads was necessary to kill off some types of starch-fermenting organisms. These cultures were abandoned.

In culture *T. batrachorum* feeds upon the bacteria present, its cytoplasm frequently being full of food vacuoles containing bacteria in process of digestion. In cultures where starch is present *T. batrachorum* feeds voraciously upon it, the cytoplasm becoming so congested with the grains that the internal organellae become displaced and twisted by the pressure. *T. hominis* and the *Trichomonas* from *M. nemestrinus* both ingested rice-starch and red blood corpuscles when fed upon them in the course of Mr Dobell's experiments.

In cultures grown at room temperature from cold-blooded animals growths of coprozoic protozoa frequently occur. These coprozoic protozoa have, presumably, passed through the alimentary canal of the frog or toad in an encysted condition and they hatch out and multiply in the medium. Of these, *Polytoma uvella*, *Heteromita* sp. and two species (one large and one small), as yet unidentified, of amoeba, have appeared most frequently. These organisms multiply very rapidly and swamp the trichomonads completely. I have found no method yet of extirpating them and have been forced to abandon such cultures. *Bodo* sp. and *Spiromonas* sp. have also appeared, but much less frequently. Both of these have always died out after a few sub-cultivations—though in some primary cultures and their first sub-cultures *Spiromonas* has multiplied enormously. Work is still in progress upon some of these coprozoic forms.

Whilst studying primary cultures of the intestinal contents of frogs and toads I was astonished to find that *Copromonas subtilis* only appeared, in small numbers, in a very small proportion of the initial cultures made, and it disappeared from these very quickly. Dobell (1908) found that it usually appeared in large numbers if the contents of the alimentary canal of *Rana temporaria* or *Bufo vulgaris* were diluted with a solution of egg-white in 0·75 per cent. NaCl and kept for a few days. In the course of some experiments upon the coprozoic protozoa I had occasion to make up my usual inspissated-serum Ringer-egg-white medium in the form of plates instead of tubes. Under these conditions I obtained good growths of *Copromonas subtilis* and, in two cultures, thick growths of *Bodo* sp. Excellent growths of *C. subtilis* and of *Bodo* sp. appeared when the intestinal content was diluted with Ringer-egg-white, if the culture was made in a flat dish—such as Dobell used. If similar cultures were made in test-tubes few or no copromonads appeared. It was shown by

Fox (1921) that *Bodo sulcatus* is influenced by the amount of dissolved oxygen present in its medium and forms aggregations in regions of optimum concentration. In my cultures in test-tubes *Bodo* sp. or *Copromonas*, if they appeared, were thickest at the top of the liquid. These few preliminary observations seem to indicate that *Bodo* sp. and *C. subtilis* are aerobic and only multiply rapidly in cultures which have a wide surface open to the air.

In examining plate cultures of horse-serum Ringer-egg-white made from intestinal contents rich in *T. batrachorum* I found that, whereas the growth of the two coprozoic flagellates was good, the trichomonads were few and dividing forms were extremely rare. *T. batrachorum* remained alive for up to 8 days in plate cultures made from faeces diluted in Ringer, or faeces diluted in Ringer-egg-white, but no dividing forms were found. Chatton (1918, 1918 *a*) working upon cultures of *Trichomastix* (= *Eutrichomastix*) from the Gecko found them to be partially, but not completely, anaerobic. Later he (1920) cultivated *Trichomonas* from the guinea-pig in cultures either covered with vaseline or without it. Hogue (1922) found that her cultures of *T. hominis* lived much longer if covered with paraffin oil; whilst Andrews (1926), experimenting upon five "species" of *Trichomonas* (*Pentatrichomonas Ardin-Delteili, T. hominis, T. cuniculi, T. muris,* and a *Trichomonas* from a monkey), found them to be *facultative anaerobes*. Hinshaw (1927) found oxygen to be harmful to *T. buccalis* and their optimum cultural conditions to be anaerobic. From my own observations it would appear that *Trichomonas can live* for days under cultural conditions with a wide surface exposed to air, but that they require relatively deep liquid with a small surface area for *rapid multiplication*.

III. THE QUESTION OF A *EUTRICHOMASTIX* STAGE IN THE LIFE HISTORY OF *TRICHOMONAS*.

In making examinations of the gut of frogs I have frequently found *Eutrichomastix batrachorum* present in addition to *T. batrachorum*, but my attempts to cultivate it have failed so far. It has been questioned by a number of workers whether *Eutrichomastix* is a stage in the life history of *Trichomonas*. The presence of both species in a number of hosts together with certain observations and experimental findings have been offered as support of the hypothesis. Dobell (1907) found only *E. serpentis* in the alimentary canal of *Boa constrictor*, but he (1910) found both *E. batrachorum* and *T. batrachorum* occurring together in the intestine of *Bufo melanostictus, Rana tigrina, Mabuia carinata, Dryophis mycterizans, Hemidactylus leschenaultii* and (1909) in frogs. He prefers to regard them as separate genera as he never found intermediate forms. Martin and Robertson (1911) found *Trichomonas* and *Eutrichomastix* in the gut of fowls. Doflein (1916) believed the two forms to be related, and thought that the presence or absence of the undulating membrane was due to internal and external conditions. He regarded *E. gallinarum* as an intermediate stage as it possesses a vestigial basal fibre. He offers no experimental data in support of his hypothesis.

Dobell (1907) noticed that in degenerating individuals of *E. serpentis* there was a tendency for the posterior flagellum to adhere to the body and thus produce a trichomonad-like form. Grassé (1926) has produced a similar phenomenon experimentally in *E. coluborum* in a slightly hypotonic Ringer (*p*H 7·5–8). Complete degeneration followed. Chatton (1920) observed in cultures of *Trichomonas* from the guinea-pig that the flagellum bordering the undulating membrane became free and thus gave rise to a *Eutrichomastix* form. When he inoculated such cultures into the peritoneum of the guinea-pig the *Trichomonas* form was resumed within a few hours. Reichenow's observations (1920) are of interest in this connection. Whilst working upon *E. lacertae* in the blood stream of lizards he found that in one individual *Trichomonas* appeared in the blood the day after death. Examinations of fresh material and of stained preparations made the day before showed no trichomonad in the blood or gut. Although Reichenow found *E. lacertae* in the gut and blood of a number of lizards he does not—with this one exception—record the presence of *Trichomonas*. *Trichomonas* has, however, been recorded from a number of species of lizards (Prowazek, 1904; Dobell, 1910; Franchini, 1921; Wenyon, 1921), and its ability to invade connective tissue, the blood stream, and liver has been described by Wenyon (1920, 1926), Pentimalli (1923)[1], Plimmer (1912) and Kessel (1925). Grassé (1926) describes the gradual development of *T. batrachorum* from a minute *Trimitus* stage (Figs. 258–262) by growth, and the formation of the undulating membrane by adhesion of a flagellum. Duboscq and Grassé (1923, 1924 *b*) believe that in the life cycle of *Janickiella Grassii* (a parasite of a termite) there exist *Trimitus*, *Eutrichomastix* and *Trichomonas* stages. Wenyon (1926) states that he has cultivated a *Trichomonas* from the frog without the appearance of *Eutrichomastix*. I myself have cultivated strains of *T. batrachorum* in pure culture (one strain for 5 months, three strains for 9 weeks, and a number of other strains for shorter periods—in each case only abandoning them, whilst in a flourishing state, because of the pressure of other work) without their form undergoing any modification other than that due to the normal changes in division—or of degeneration and death in old cultures. *Trimitus* or *Eutrichomastix* forms never appeared.

During the last 15 years a number of species of *Trichomonas* from various hosts have been cultivated. In 1913 Escomel claimed to have cultivated *Trichomonas intestinalis* (= *T. hominis*) in a lettuce broth. From the description of the experiment it is probable that he was dealing with a free-living flagellate—a contaminant. Pringault (1920) was unable to repeat this experiment. Lynch (1915, 1915 *a*) obtained "considerable multiplication" of *T. hominis* and *T. vaginalis* in acid broth at 30° C. but, to my knowledge, this has not been confirmed. Since then he (1922, 1924) has cultivated *Trichomonas* upon a variety of media including liquid blood serum, ascitic fluid, pleural fluid and fluid from an ovarian cyst.

[1] Wenyon (1926) refers to Pentimalli's observations. Figures of the flagellate are given in the original paper.

Trichomonas has been cultivated by the following authors and others (see Table I). In searching the extensive literature I have found, with the exception of Chatton's observations, no reference to the appearance of *Eutrichomastix* forms in pure cultures of *Trichomonas*. In some hosts, *e.g.* man, in which infections of *Trichomonas* are not rare, *Eutrichomastix* forms are not found. To my knowledge only one reference exists of *Eutrichomastix* in man. Chatterjee (1917) described and figured a flagellate which he named *Trichomastix hominis*. Most of the individuals were round; some had three anteriorly and one posteriorly directed flagellum, whilst others had only two anteriorly directed flagella in

Table I.

Name of worker	Date of publication	Strain of *Trichomonas*
Ohira and Noguchi ...	1917	*Tetratrichomonas hominis*
Pringault	1920	*Trichomonas hominis*
Reuling	1921	*T. vaginalis*
Hogue	1921, 1922	*T. hominis*
Lynch	1922, 1924	*T. hominis, T. caviae*
Hegner and Becker ...	1922	*T. hominis*
Reichenow	1923	*T. intestinalis* = *T. hominis* and *Trichomonas* from *Herpestes mungo; Macacus sinicus;* Chimpanzee, cat and pig
Kofoid and Swezy ...	1923	*Pentatrichomonas Ardin-Delteili*
Boeck	1924	*T. confusa* = *T. hominis, T. gallinarum*
Brumpt	1925	*Trichomonas* from cat
Dobell	1925, 1928	*T. hominis, Trichomonas* from *Macacus sinicus* and *M. nemestrinus*
Thomson and Robertson	1925	*T. hominis*
Drbohlav	1925	*T. sanguisugae*
Tanabe	1925	*Trichomonas* from man, rat and owl
Wenyon	1921 *a*, 1926	*Trichomonas* from *Testudo radiata, Python molurus* and frog
Andrews...	1926	*Pentatrichomonas Ardin-Delteili, T. hominis, T. cuniculi, T. muris,* T. sp. from monkey
Tanabe	1926	*T. augusta; T. Prowazeki; P. Ardin-Delteili; T. Felis, T. oti*
Hinshaw...	1927	*T. buccalis*
Kessel	1928, 1928 *a*	*Trichomonas* from *Macacus rhesus*
Andrews...	1929	*T. vaginalis*

addition to the posteriorly directed one. There was, apparently, no axostyle nor cytostome. Dobell and O'Connor (1921) are of the opinion that it was not a *Eutrichomastix*, and Wenyon (1926) corroborates this. In the present state of knowledge it seems wiser to hold *Trichomonas* and *Eutrichomastix* as separate genera; to base all future observations relating to this question upon "pure" cultures and infection experiments with these cultures of clean animals (whose negative condition has been carefully tested), and to avoid any speculations upon life histories based on observations upon animals which may harbour a number of distinct species of flagellates.

IV. Morphology and division of *T. batrachorum*.

An excellent and well-illustrated description of the general morphology of this species was published by Dobell (1909). The average size of fixed individuals from my cultures was smaller than the size given by Alexeieff (1911) for *T. batrachorum*. He gave the average length as 14–18μ, whereas in the strains I studied I found it to be between 7–14μ in length × 4–7μ in width, "giants" of 18–22μ long were plentiful in my cultures however. Such giants are found in many species of intestinal flagellates.

The cytostome is an elongated slit lying close against the edge of the nucleus at the anterior end of the body. It can be observed clearly in some living animals and in some individuals fixed with warm Schaudinn's fluid, but in preparations fixed with cold Bouin's fluid it is scarcely ever seen (though this fixative gives excellent results for other structures). That the cytostome is capable of enormous distention is proved by the huge starch grains which are ingested.

Normal living individuals can be observed for long periods under waxed-down coverslips in culture fluid. In such preparations the nucleus can be seen at the anterior end as an oval structure of greater density than the surrounding cytoplasm, with, in favourable preparations, the karyosome in the centre surrounded by scattered granules. The axostyle can be perceived clearly. It arises from the basal granules, and lies closely pressed to one edge of the nucleus. Immediately behind the nucleus it is broadest. It rapidly tapers, and its pointed end projects some distance beyond the end of the body (Fig. 1). In some preparations (Fig. 2) the axostyle has the appearance of arising from the posterior end of the nucleus, but careful study of individuals such as Fig. 1 and of many living trichomonads has assured me that the axostyle lies behind, or to one side, of the nucleus. Observations upon the living animal cannot fail to impress upon the observer the great mobility and capacity for change of form of this flagellate. Any question of the axostyle being *rigid* is quite disproved by the gymnastics of the living creature; for not only is it able to distort itself laterally in squeezing itself sinuously through narrow spaces, but individuals frequently twist themselves "head" over on to "tail" (if such an expression is permissible of such a creature!) so that the axostyle is bent completely upon itself, a smooth, sliding movement occurring simultaneously from posterior to anterior, so that the position of the bend is continually changing. I have never seen the lashing movement of the axostyle described by Kofoid and Swezy (1915) in normal animals, nor have I observed the amoeboid movements of the body described and figured by Kuczynski (1914) for *T. augusta* in vegetable broth. In old cultures the flagellates frequently become rounded, the undulating membrane appearing as a rippling girdle. Unlike *T. augusta* the axostyle of *T. batrachorum* does not contain granules but the posterior tip sometimes stains deeply with iron haematoxylin.

T. batrachorum is described as having three anterior free flagella of equal size and one posteriorly directed one attached to the edge of the body by a

membrane. This membrane-flagellum projects free beyond the end of the body (Figs. 1, 4, 6). In my cultures, however, of *T. batrachorum* from both the frog and toad flagellates with three or four anterior flagella were present in approximately equal numbers. These flagella were of equal length. Very rarely I found individuals with five flagella. Alexeieff (1909) described a *Trichomonas* (*T. prowazeki*) from the hind gut of *Salamandra maculosa*, *Triton cristatus*, and *Alytes obstetricans*, and later (1910) from *Box salpa*, which differed from *T. batrachorum* in that it had four flagella of unequal length. Kofoid and Swezy (1915) found this species in *Diemyctylus torosus*. I myself have seen it in the gut of *Salamandra maculosa*. The flagella of the individuals in my cultures of *T. batrachorum*, where four were present, were equal in length. There was no other difference in detailed structure whatsoever and I cannot believe that I was dealing with a mixture of two species. In my cultures of *T. hominis* and of *Trichomonas* from *M. nemestrinus* I have found individuals with either three or four flagella—occasionally in the latter strain individuals with five flagella appeared. There was no reason for supposing that these cultures were of mixed species. The classification and specific names of the genus *Trichomonas* have passed through many vicissitudes owing to the basing of species upon the number of flagella. Dobell (Dobell and O'Connor, 1921) gives a list of the synonyms of *T. hominis*. Alexeieff (1911) placed *T. batrachorum* into *Trichomonas, sensu stricto*, which he defined as having three anterior flagella, whilst trichomonads with four flagella he (1914) places in the sub-genus *Tetratrichomonas* Parisi. Kofoid (1920) regards it as necessary to keep the name *Trichomonas* for flagellates with four flagella and proposes *Tritrichomonas* as the generic name for the trichomonads with three flagella. Dobell (Dobell and O'Connor, 1921) points out that the type species is *T. vaginalis* which has four flagella (*vide* Kunstler, 1884; Reuling, 1921; Hegner, 1925; Andrews, 1929). Andrews has pointed out that, in culture, *T. vaginalis* is morphologically indistinguishable from *T. hominis*. Duboscq and Grassé (1924 *a*) found that the flagellum of *T. trypanoides* split up into two, three or four elements. They believe therefore that the division of sub-genera of *Trichomonas* upon the basis of the number of flagella is not warrantable. As I have been unable to find any morphological differences between forms with three or four flagella I believe that this difference may arise accidentally during division and is of no specific and still less of generic or sub-generic consequence.

In stained preparations of *T. batrachorum* the nucleus of individuals not preparing for division can be seen (Fig. 1) at the anterior end of the body, as an oval structure with a definite nuclear membrane. There is a definite karyosome, central in position, and a number of chromatin granules varying in size scattered through the nucleus. In cultures where the peak of the rate of multiplication has been passed and dividing forms are rare, individuals with nuclei of this type are plentiful, but in young cultures, where the division rate is high, the phase seems to be of short duration and individuals in the earliest prophase are most numerous.

The flagella arise from a large blepharoplast at the extreme anterior end of the body (Figs. 1–5). This normally is not a perfectly spherical body and has the appearance (Fig. 2) of being formed by the coalescence of three or four granules. In my preparations I found that the blepharoplast lies close against the nuclear membrane (as figured by Dobell, 1909) and no rhizoplast can be detected between it and the karyosome.

The basal fibre runs from the blepharoplast to the posterior end of the body. It is usually narrow immediately behind the blepharoplast and tapers near its posterior end. It lies immediately below the undulating membrane (Figs. 1–5) and the membrane flagellum becomes free close to its posterior end. In some individuals it appears more massive than in others; in some it is quite straight (Fig. 1), in others it is slightly sinuous (Fig. 9).

The axostyle, whose position has been described above, is usually colourless, but occasionally it stains lightly with iron haematoxylin. The posterior tip is often stained. Unlike the axostyle of *T. augusta* it contains no siderophilic granules nor has it a club-shaped anterior end.

When division is about to begin the granules in the nucleus become more numerous (Fig. 2). The karyosome decreases in size and the extrakaryosomic granules become larger and begin to mass together. Finally the karyosome disappears and the nucleus contains a number of granules varying in size. Sometimes these seem to have flowed together to form a definite spireme, as in metazoa, but this condition was rare (Figs. 8, 9). In the majority of cases six large, discrete granules (or prophase chromosomes), varying in size amongst themselves, were formed (Fig. 4). The chromatin stains intensely. In all individuals where the granules were arranged so that an exact count could be made six were invariably present. This prophase appears to be of long duration and examples were plentiful in cultures where the division rate was high. Immediately after the formation of the prophase chromosomes the blepharoplast divides (Figs. 6, 7). In some cases the daughter blepharoplasts appear equal in size, but usually they appear, at first, to be quite unequal. Working upon *T. muris* Wenrich (1921) noticed that the daughter blepharoplasts were frequently unequal. From the posterior edge of one of the daughter blepharoplasts a delicate line appears. This rapidly elongates in the posterior direction and becomes more accentuated (Fig. 6). This is the new basal fibre. In a few individuals this new fibre was formed (Fig. 5) before the formation of the six chromosomes or division of the blepharoplasts, in others (Fig. 8) it was formed coexistent with a definite spireme. In other individuals (Fig. 9) the separation of the daughter blepharoplasts was well advanced, whilst the new basal fibre was still in a nascent state.

The daughter blepharoplasts separate, but remain connected by a deeply staining strand, the centrodesmose (Figs. 7, 9), which elongates as the blepharoplasts move apart. If there are three flagella two remain with one daughter blepharoplast (Fig. 11) and one with the other, or if four flagella be present then each daughter blepharoplast takes two (Fig. 7). To one daughter

blepharoplast is assigned the original basal fibre and its membrane and flagellum, whilst to the other are attached the newly developed ones. Exactly how the new flagellum and membrane are formed I have not seen, but from evidence from the other species I conclude that the new flagellum grows out along the basal fibre from the daughter blepharoplast. Simultaneously with the separation of the daughter blepharoplasts and the formation of the new membrane (Fig. 7) a degeneration of the old axostyle takes place. With the disappearance of the axostyle the body becomes rounded (Figs. 7, 10, *et seq.*), suggesting that this organ, in spite of its great pliability (p. 136), is a form-giving element as Dobell (1907, 1909) advocated. Individuals (Figs. 12, 16) do sometimes keep their "trichomonad" form after the axostyle had vanished, but this is unusual.

The nuclear membrane persists throughout division. It will be noticed (Figs. 11, 13, *et seq.*) that the original basal fibre appears less massive than in the resting and early prophase stages. This is very striking in some individuals.

The blepharoplasts move apart so that they come to lie on either side the nucleus. In favourable preparations (Figs. 11, 17, 18) it can be seen that each blepharoplast gives rise to two small granules. One granule of each pair lies at the opposite ends of the centrodesmose. These granules are therefore true centosomes. The remaining granule of each pair is connected with the motor organellae and the structures appertaining thereto. These granules are true basal granules. Each basal granule and centrosome lies in juxtaposition to one another. In a few cases (Fig. 11) where they were not in close contact they appeared to be joined by a minute rhizoplast; but the details of such minute structures are necessarily obscure, even with the best optical instruments, and it is impossible to lay much stress upon them. Dobell (1909) recognised the division of the daughter blepharoplasts into basal granules and centrosomes and figures this (Fig. 21) at the metaphase. After completion of the anaphase the granules must reunite, since all through the telophase the granules at either end of the centrodesmose (Figs. 19–22) are single.

I was unable to detect spindle fibres at any stage. The chromosomes are at first dispersed irregularly in the nucleus (Figs. 11, 13), but later they appear to come together to form an equatorial plate (Fig. 14), the nuclear membrane being frequently definitely spindle-shaped.

I am of the opinion that the formation of a spireme is rare and that normal division can proceed without it. But in individuals where such a stage has occurred somewhat looped chromosomes occur (Fig. 10) prior to the formation of the equatorial plate, and are, doubtless, formed by the breaking up of the spireme.

The division of the chromosomes does not take place strictly simultaneously since individuals are found (Fig. 16) where some have separated and others have not. The chromosomes appear to become constricted into a dumb-bell shape—and so to divide. Individuals (Figs. 15, 17) however suggest that division of the chromosomes is longitudinal. Possible aberrant individuals

were found, particularly in the division of "giants" (Fig. 12). This I interpreted as the breaking up of a spireme into isolated "chromosomes," but the size of these seems small in proportion to the body mass. Fig. 17 also depicts a "giant," and here the chromosomes have the appearance of a longitudinal splitting. Anaphases (Fig. 18) were rare, but when found showed twelve rounded chromosomes diverging in equal numbers towards the centrosomes. The wealth of material at the prophase, metaphase, and telophase and the rarity of examples at the anaphase persuade me that this phase is of brief duration.

In the earliest telophases the daughter nuclei contain six separate chromatin granules—the daughter chromosomes (Fig. 19), but as the phase proceeds (Figs. 20, 21, 22) these granules become more compact so that it is impossible to count them. In late stages in the telophase (Fig. 22) the chromosomes are often arranged in finger-like processes. Such a stage is figured by Grassé (1926). Finally after somatic fission (Figs. 23, 24) the chromatin accumulates into a large central mass surrounded by a clear area, and, from this, I conclude, the normal nucleus (Fig. 1) is gradually reconstructed, though I have not been able to follow the stages.

During the telophase the body appears to be very plastic and continual change of form occurs. This can be observed in living individuals, and is apparent in fixed preparations. The body frequently shows no constriction nor other sign of impending division until the process is actually beginning. A constriction makes its appearance quickly across the centre of the body, and after a few quick tugging movements in opposite directions by the two ends of the body complete division results. The rapidity of the process has to be seen to be realised. I have only once obtained a preparation of an individual in the act.

Before the formation of the equatorial plate the old axostyle has disappeared, and the delicate rudiments of the new axostyles become visible during the telophase. They arise (Figs. 20–22) as faintly staining outgrowths from the blepharoplasts: they lie on the outer edge of one side of the nuclear membrane, and, before they extend beyond this, are almost impossible to distinguish. In searching many preparations I noticed that in many cases one daughter axostyle grows more rapidly than the other. They appear, in the slightly later stages, as homogeneous siderophilic structures. When the body has divided (Figs. 23, 24) they begin to lose their affinity for stains and gradually broaden, showing the pale, tapering appearance of the mature axostyle.

The centrodesmose persists until after the body has divided, when it gradually disappears. The coincidence of the disappearance of this intensely staining centrodesmose with the increase in size of the equally intensely staining basal fibre has impressed me.

The new flagella grow out from the blepharoplasts during the metaphase, anaphase or telophase. Their formation (Fig. 17 *et seq.*) seems to follow no particular rule. Frequently actual division of the body occurs (Fig. 24) without the normal number of flagella having been attained. Hinshaw (1926), working upon cultures of *T. buccalis*, found that when the division rate was high

"daughters may be freed without an axostyle, with only two flagella, and with a compact nucleus such as characterises the telophase." My findings agree with this statement except that I always found an axostyle present, though in a number of cases it was very little developed. As I never found mature trichomonads with only two flagella I conclude that this deficiency is rapidly righted. It is partly this haphazard manner in the formation of the new flagella which has led me to suppose that the possession of three or four flagella is a matter of chance during division and of no taxonomic importance.

The cytostome seems to disappear at the beginning of division, but I have been unable to discover how it is reformed.

I have been unable to discover any morphological differences between *T. batrachorum* from frogs and toads.

V. MORPHOLOGY AND DIVISION OF *TRICHOMONAS* SP. FROM *M. NEMESTRINUS*.

The cultural history of this strain from *M. nemestrinus* has been given above (p. 130). The *Trichomonas* is smaller than the average sized *T. batrachorum* as it varies between 8 and 10μ in length. As in *T. batrachorum* "giants" occur sometimes in the cultures, but I have found them less frequently in this strain. Fig. 30 shows the anterior end of such a giant in an early stage of division. They appeared quite normal in structure. This strain (known since its recovery from *M. rhesus* as the R.T. strain) is a robust-looking *Trichomonas* with a very firm appearance both when alive or when stained.

The greater number of individuals have four free flagella (Fig. 25), but an appreciable proportion have three (Fig. 28). Very occasionally, whilst counting flagella in preparations treated with iodine, I have found individuals with five. The blepharoplast appears to be composed of a number of granules, probably three or four. The course of the axostyle is more difficult to trace in this strain than in *T. batrachorum*. At the posterior end it projects from the body for 3 or 4μ, sharply pointed. At its anterior end its outer edge appears to be close against the nuclear membrane (Figs. 25–27), but I have been unable to trace its whole breadth across the nucleus as (Fig. 1) in *T. batrachorum*. From its mode of development, however (Figs. 36, 37), I am convinced that its position in relation to the nucleus is similar to that of the axostyle in *T. batrachorum*.

The basal fibre tapers towards its posterior end and is also frequently narrow near its point of insertion in the blepharoplast. The membrane and its flagellum lie above the basal fibre, the flagellum describing three or four undulations along the body.

The cytostome is a slit, lying at the anterior end of the body close to the nucleus and difficult to distinguish in fixed material. The R.T. strain feeds upon bacteria and the body usually contains many in process of digestion.

The "resting" nucleus (Fig. 25) contains a conspicuous central karyosome surrounded by a pale halo. There are no extrakaryosomic granules. The first stage in division is the formation of a number of chromatin granules outside

the karyosome. These seem to be formed, at first, immediately outside the halo (Fig. 26), and are sometimes quite massive. They form large scattered granules (Figs. 27–30) and the karyosome gradually disappears. The granules are so irregular in size and so heaped together that I have found it impossible to make an exact count, but five or six seems to be the number. The new basal fibre is formed, as in *T. batrachorum*, as an outgrowth from the blepharoplast (Figs. 30–32) either before its division, while it is constricting for this, or immediately after. Figs. 31 and 32 show early stages in the development of the new membrane flagellum and its undulating membrane. They appear to grow out along the basal fibre from the blepharoplast.

A similar apportionment of the free flagella between the daughter blepharoplasts (Figs. 30, 33, 35) to that in the division of *T. batrachorum* occurs.

At the end of the prophase the axostyle becomes less distinct (Fig. 32) and finally (Fig. 33) disappears. The body then becomes rounded. The daughter blepharoplasts with their motor organellae and related structures move apart over the nuclear membrane (which persists throughout division), but they remain connected with one another by the centrodesmose. During the metaphase, as in *T. batrachorum*, each daughter blepharoplast divides into two granules (Fig. 34), giving rise to true centrosomes at the ends of the centrodesmose, and to basal granules at the base of the flagella and basal fibre.

As in *T. batrachorum* spindle fibres were not perceptible. The chromosomes were too irregularly placed (Fig. 33) for a definite count to be made, but, as at the prophase, they again appeared to be either five or six.

In this strain, as in *T. batrachorum*, anaphases are very rare, and in the few I found (Fig. 35) the "chromosomes" appear to straggle irregularly towards the poles. The centrosomes and basal granules reunited to form the blepharoplasts.

Telophases were numerous. The chromosomes appeared, at first, to be irregularly and loosely arranged (Fig. 36), but later (Fig. 37) they condensed to form a solid mass. The centrodesmose persists until the body has divided (Figs. 36–39), after which it is gradually absorbed. The new axostyles are formed as delicate outgrowths from the blepharoplasts alongside the nuclear membrane, one being formed, usually (Fig. 36), a little in advance of the other. As in *T. batrachorum* they lose their affinity for stains as they grow, and become pale like the adult structure.

The new flagella are formed as spiky outgrowths from the blepharoplasts during the telophase (Figs. 36, 37) or after the division of the body. In this strain too their formation appears to follow no particular rule.

Examples of multiple fission (see *T. hominis*, p. 145) have not been met with in this strain, but a few examples of delayed division have been observed. These are similar to such forms (Figs. 56, 57) in *T. hominis*. Fig. 38 shows a stage in the process. Here the two daughter nuclei lie at the anterior end, the daughter axostyles are developing and the centrodesmose is looped. In more advanced stages this latter structure begins to be absorbed from the basis of

the loop. However, the condition is rarer in this strain than in *T. hominis*, and as the process appears to be similar it will be described in more detail later[1].

VI. MORPHOLOGY AND DIVISION OF *T. HOMINIS*.

A list of the chief synonyms and a short historical account of *T. hominis* Davaine is given by Dobell and O'Connor (1921). Good descriptions of the general morphology of *T. hominis* have been given by Dobell and O'Connor and many other workers. I shall therefore not describe it in detail. The strain of *T. hominis*, the history of which has been given above (p. 130), which I have studied was, on the average, smaller than the R.T. strain, and, apart from this slight difference in size, had a much more delicate appearance. It had either three or four free flagella arising from the blepharoplast. In normally stained preparations this blepharoplast appears either as a large granule (Fig. 42) at the point of insertion of the flagella, as if made up of several granules (Figs. 44, 45), or, in a large number of cases, it appeared as if divided into two parts (Fig. 41), a larger granule from which the flagella and basal fibre arose and a smaller granule at the anterior end of the axostyle. However, in a few individuals, from which the stain had been greatly extracted, the blepharoplast was seen to be composed (Fig. 43) of a group of three, probably four, discrete tiny granules. Two of these gave rise to the anterior flagella, whilst from a third granule arose the basal fibre and its flagellum. The fourth, if actually a separate granule, was so obscured by the others that it was impossible to study its relationship to the organellae. Unfortunately the preparation was so pale that the course of the axostyle was not visible. It is therefore quite evident that the blepharoplast, in this species, is a composite structure, and it is quite possible that it is similarly constituted in *T. batrachorum* and the R.T. strain.

The resting nucleus possesses an intensely staining karyosome (Figs. 41–43), approximately central in position. It is surrounded by a halo. Usually no definite extrakaryosomic granules are present, but occasionally a few extremely fine ones can be seen. The earliest stage in division, and evidently a prolonged one, is the appearance of chromatin granules (Fig. 44) outside the karyosome. A number of large, irregularly shaped granules result and the karyosome (Fig. 45) disappears. The granules become compact and definite in number. It is difficult to count them exactly but five or six seems to be the probable number. Sometimes they are comparatively enormous and very irregular, particularly in "giants" (Fig. 48). The new basal fibre is formed from the blepharoplasts in precisely the same manner as in *T. batrachorum* or the R.T. strain (Figs. 46–48). The undulating membrane and flagellum appear to arise in a similar way to those organellae in the R.T. strain. I have not observed the method of formation of the two daughter blepharoplasts from the group which constitutes the parent.

[1] Cysts were never found in the cultures, but rounded forms (Fig. 40) sometimes occurred. That these were not about to encyst but were early stages of degeneration was proved by watching them. Such forms died and disintegrated.

During the prophase the axostyle gradually disappears and the body becomes rounded (Fig. 50), the daughter blepharoplasts move apart across the nuclear membrane (Fig. 49) but remain connected by the centrodesmose. Each daughter blepharoplast bears a basal fibre, a membrane and its flagellum, and either two flagella or one flagellum depending upon whether the total number before division was three or four. As in the R.T. strain and *T. batrachorum* the old basal fibre appears, at this stage, less massive than in individuals not undergoing division. No spindle fibres are formed (Figs. 50, 51), though at the metaphase the nuclear membrane is spindle shaped. The daughter blepharoplasts (Fig. 51) divide into two, as in the strains described above, forming two basal granules and two centrosomes. The chromosomes are rod-like, but I have been unable to count them. Anaphases were very rare in my preparations. They show (Fig. 52) the chromatin in granules moving towards the poles, at which the centrosomes and basal granules have reunited. In the early telophase (Fig. 53) the chromatin granules appear loosely packed in the nucleus, but later (Fig. 54) they form dense masses. New axostyles are formed from the blepharoplast, close to the edge of the nuclear membrane (Figs. 54, 55). Division in *T. hominis* therefore follows the same rules as in the R.T. strain and *T. batrachorum*.

In my cultures of *T. hominis* I have observed a large number of individuals which appear to have all their organellae duplicated (Figs. 56, 57). These figures show two forms selected at random, but individuals differ considerably in appearance in the disposition of their organs, some having one set of organs exactly superimposed upon the other so that only careful focussing reveals their dual nature. In spite of these varieties of positions however the nuclei never lie at opposite poles of the body as they would if preparing for division of the body. Also, whatever the position of the nuclei and other organellae the posterior ends of the axostyles invariably lie so close together that, at a first glance, one might assume that the axostyle was dividing; but careful focussing proves them to be merely superimposed, or even twined about each other, but quite separate structures. These double individuals occur in cultures of all ages. Hinshaw (1926) says that he only found "duplex individuals" in senescent cultures in *T. buccalis*, but I have not found this so for cultures of *T. hominis*.

A rather high rate of abnormality exists amongst these double individuals, a proportion of them possessing hypertrophied nuclei, such as are sometimes found in single individuals in old cultures. Careful search of many preparations containing such double individuals, however, has failed to reveal any nuclear, or body changes, which might be associated with a sexual process. Frequently one or both nuclei contain extrakaryosomic granules, as if preparing for division, and individuals are found (Fig. 58) in which both nuclei are dividing. It will be noted that the division is following a normal course (*i.e.* the axostyles have disappeared, the centrodesmose is formed and the disposition of the basal fibres is as in ordinary division). Telophases of such double individuals (Fig. 59) have been found. In the cultures multinucleate individuals (= somatella, Kofoid and Swezy, 1915) containing three, four or six individuals have been

found (Fig. 60) and these contain a normal number and arrangement of the organs except that, in all cases, the axostyles converge and lie close together at their posterior ends as if attracted by one another. I have never observed the actual division of the body of these multiple individuals.

I found the proportion of double individuals to be much larger than of multiple individuals, and it seems highly probable that a large number of the former do not undergo further nuclear division. They must either degenerate—or divide into two individuals. That this delayed division of the body is not an essential phase in the division of *T. hominis* I am sure, because, preparations from some cultures where the division rate was high failed to reveal any double individuals.

A number of references to, or descriptions of, multiple fission occur in the literature of *Trichomonas*. Prowazek (1904, T. IV, figs. 91–92) describes and figures individuals with three sets of organs undergoing what he describes as simultaneous multiple division. Dobell (1907) observed multiple individuals containing four sets of organs in *E. serpentis*. Kuczynski (1914, 1918) never observed the phenomenon though he studied species (*T. muris*, and *T. augusta*) from which it has been described, nor did Wenrich (1921) observe it in his detailed study of the former species. Kofoid and Swezy (1915) describe multiple fission in *T. augusta*, *T. muris*, *T. prowazeki*, and *E. serpentis*. They found it, normally, in certain hosts, while in others no sign of it occurred. They describe somatella consisting of two, four, and eight sets of organs. In their figures the posterior ends of the axostyles do not converge as I found in *T. hominis*. They describe the detachment, singly, of individuals from the somatella. Reuling (1921), working upon *T. vaginalis*, saw a multiple individual consisting of four sets of organs. Kofoid and Swezy (1923) observed somatellae consisting of two, four, and eight sets of organs in *Pentatrichomonas Ardin-Delteili* but do not figure them. Andrews (1925) saw multiple individuals in one host whilst working upon *T. termopsis*, but these never contained more than four sets of organs. Tanabe (1926) failed to find such forms in any of the species he studied. Cleveland (1928) observed multiple division "thousands of times" in *T. fecalis*. He describes forms possessing from three to sixteen nuclei and saw division stages of the nuclei. He states that he was able to produce them experimentally by concentrating the cultures by centrifuging.

I never observed multiple fission in *T. batrachorum* either in the rectal content of frogs and toads or in any of my strains of that species in culture; nor did I ever see double individuals in such cultures. The above summary of the literature shows that it may occur in trichomonads from a variety of hosts both cold- and warm-blooded, and in a variety of species of the flagellate. That it is not an essential part of development is proved by its absence (in species in which it is known to occur) from many individual hosts.

VII. Comparative account of division in the genus *Trichomonas*.

Division has been observed in a number of species of *Trichomonas*, but the accounts vary in several essential points.

The blepharoplast. In the three trichomonads which I have studied (*T. batrachorum*, R.T. strain and *T. hominis*) the blepharoplast had a lobed outline and appeared to be formed from three or four separate granules closely aggregated. These granules could be seen, in suitable preparations of *T. hominis*, as discrete spheres. In *T. batrachorum*, the R.T. strain and the majority of individuals of *T. hominis* the blepharoplast lay pressed against the nuclear membrane. In individuals of *T. hominis* where the nuclear membrane did not touch it I could detect no rhizoplast between them. In all three trichomonads the blepharoplast divided early in the process. In *T. batrachorum* division was usually unequal and subsequently the smaller daughter gradually increased in size. The daughter blepharoplasts were connected by a centrodesmose. During the metaphase, in all three trichomonads, the daughter blepharoplasts each divided to form two granules, one of these, the true centrosome, was attached to its fellow at the opposite pole of the nucleus by the centrodesmose, but was not connected to any other structure, whilst the other granules, the true basal granules, were attached to the basal fibre, its membrane and flagellum and the free flagella. The two granules lay in proximity to one another and reunited before the commencement of the telophase.

Dobell and O'Connor (1921) describe the blepharoplast of *T. hominis* as a group of three or possibly more small granules, and Hegner (1925) says that the blepharoplastic granules of *T. vaginalis* are three, four or five in number.

A variety of forms and changes appear to occur in the blepharoplast of different trichomonads and closely related forms. In *Retortamonas orthopterorum* Wenyon emend 1926 (= *Monocercomonas orthopterorum* Bělař emend = *Trichomastix orthopterorum* Parisi), which is somewhat similar to a *Eutrichomastix*, Bělař (1916) describes two basal granules from which the flagella arise and in one of which the axostyle ends, and which are normally connected by a centrodesmose. At division they act as true centrosomes. Wenyon (1907) described the blepharoplast of *T. muris* as two "closely lying granules" which divide prior to division of the nucleus but remain connected by a fibre (= centrodesmose). Kuczynski (1914) believed that each flagellum arises from a separate basal granule in *T. muris* and *T. augusta*; and in *T. muris* (T. 12, Fig. 51) he once saw two rows of three granules which he considered might be a stage in division. He described the centrodesmose connecting the daughter granules. Wenrich (1921) said that the blepharoplast is composed of either one or two granules, and at division the new blepharoplast (smaller than the other) appears to be budded off the original granule but remains connected by the paradesmose (= centrodesmose). He does not describe a division into centrosome and basal granule.

In *E. batrachorum* and *T. batrachorum* Dobell (1909) described the ble-

pharoplast as a double granule which divides early in the process of division and moves apart connected by the centrodesmose. He noted in *T. batrachorum* (Fig. 21) the dual nature of the daughter granules at the metaphase such as I have described above. Grassé (1926) said that the blepharoplast of trichomonads is simple in the resting stage. He observed its division in *T. batrachorum*, the connecting centrodesmose, and the division of the daughter blepharoplasts into centrosomes and basal granules.

In *T. augusta* Kofoid and Swezy (1915) described the blepharoplast as a single sphere which, during the division process, divides. A division of the daughters into basal granules and centrosomes may ensue. They found, however, considerable difference in individuals in the stage at which this second division may occur, and they believe it to be of short duration and not obligatory. In *Pentatrichomonas Ardin-Delteili* they (1923) described a primary and secondary blepharoplast connected by a rhizoplast. From the primary one arise the independent flagellum, the parabasal body (= basal fibre) and possibly the axostyle, whilst from the secondary blepharoplast arise the four anterior flagella. The primary blepharoplast is united by a rhizoplast to a minute centrosome on the nuclear membrane. Division is not described.

In *T. buccalis* Hinshaw (1926) described the blepharoplasts as consisting of a primary central granule giving rise to two central flagella, a secondary ventral granule giving rise to the undulating membrane, basal fibre and the independent ventral flagellum, and a secondary dorsal granule giving rise to the axostyle and dorsal flagellum. A rhizoplast joins the primary central granule to the nuclear membrane and a minute centrosome lies at the junction of the nuclear membrane and the rhizoplast. The centrosome divides before the blepharoplast and the daughter centrosomes are connected with each other by a centrodesmose and with the "condensed dividing blepharoplast by a delicate rhizoplast."

In *T. termopsidis* Andrews (1925) described the blepharoplast as single. At division it releases the centrosome, after which it divides. The centrosome is connected to the daughter blepharoplasts by two rhizoplasts. The centrosome then divides forming a centrodesmose between the two daughters as they move apart.

In *Ditrichomonas termitis* Cutler (1919) described two distinct granules, one, the blepharoplast bearing the two free flagella, whilst the second, or membrane granule, bears the basal fibre and its flagellum. This species differs from the other trichomonads in that the flagella are duplicated as the primary act of division and it is not until they are fully grown that the blepharoplast divides. The membrane granule also divides. One of the daughter blepharoplasts divides again producing a centriole, which migrates to the nuclear membrane and divides. The daughter centrosomes are connected with each other and with the blepharoplasts by rhizoplasts, the one between the centrosomes being the centrodesmose.

From these descriptions of division in *Trichomonas* it would appear that in

the species studied so far, with the exception of *T. muris* and *T. caviae* (Tanabe's (1925) description of this species agrees with that of *T. muris* by Wenrich, 1921), a centrosome is present during division. In a number of species (*T. batrachorum*, *T. hominis*, *Trichomonas* from *M. nemestrinus*) it only separates from the basal granule for a brief period in the division. In cases, *e.g. T. hominis*, where the compound nature of the blepharoplast has been demonstrated the actual method by which the centrosome separates from the basal granules is unknown. A careful study of my preparations of *T. hominis* has failed to show a composite structure of the blepharoplast apart from the resting stage, or early prophase. Hinshaw's (1926) observation that in *T. buccalis* the blepharoplasts condense during division is perhaps pertinent. In *Pentatrichomonas Ardin-Delteili* and *T. buccalis* the centrosome is always present as a separate sphere.

The basal fibre. In the three trichomonads which I have studied the new basal fibre is formed as an outgrowth from the blepharoplast, or one of its daughters, during the early prophase. The new membrane and its flagellum appear to be formed along it also as an outgrowth from the blepharoplast. Amongst the earlier descriptions a difference of opinion existed concerning the origin of these structures. Wenyon (1907) saw the new structure at an early stage in *T. muris* but was not certain of its method of development. He suggested that it was split off from the original fibre, whereas the undulating membrane, like its flagellum, he believed to be a new structure. Dobell (1909) thought that the new undulating membrane arose by division of the old. He was uncertain of the origin of the new basal fibre; he did not believe that it arose by division of the old but suggested that the old basal fibre was absorbed and new ones formed. (I have pointed out above (p. 139) the decrease in size in the basal fibre during division. It is not *absorbed* but it often becomes so fine that it is difficult to trace.) Kofoid and Swezy's account (1915) is confused by their terming the basal fibre the *parabasal*. This structure is entirely separate, and only seen in preparations specially prepared (see Grassé, 1926). In preparations of *T. batrachorum* fixed with weak Flemming's solution I have seen it as a bag-like structure hanging from the blepharoplast and lying to one side of the nucleus. Kofoid and Swezy described the marginal flagellum as dividing longitudinally, whilst the basal fibre they described correctly as arising as an outgrowth from the blepharoplast. The accounts of Martin and Robertson (1911), Kuczynski (1914, 1918), Cutler (1919), Wenrich (1921), Andrews (1925), Tanabe (1925 and 1926) and Grassé (1926) of the outgrowth of the new basal fibre from the blepharoplast in a number of species of *Trichomonas* agree. According to Hinshaw's (1926) account the formation of the new basal fibre is delayed in *T. buccalis* until the metaphase.

The axostyle. In my three strains of *Trichomonas* the old axostyle was absorbed before the end of the metaphase and the new structures grew out from the blepharoplasts during the telophase. In the early stages the new axostyles stain with iron haematoxylin but they are extremely delicate, and difficult to

detect. Wenyon (1907) believed that the axostyle was duplicated by longitudinal division of the existing one, but he offered no real evidence in support of this. In Figs. 15 and 21 he obviously confused it with the centrodesmose. Kofoid and Swezy (1915) described division of the existing axostyle in *T. augusta*, and *T. muris*, though for *T. muris* they only gave one illustration of the process (Fig. 60). The splitting in *T. augusta*, according to their description, occurs late in the telophase, but in the greater number of their figures (Figs. 31–40) the nuclei have completed their reorganisation. In both these species the authors have described multiple fission, and, in my strains, cultures which produced cases of multiple fission also produced double individuals. The idea suggests itself that the figures represent double individuals with the axostyles superimposed and not individuals in which the axostyle is splitting. In their figures the axostyle is present all through division, but Kuczynski (1918) figures stages in the division of the same species (Figs. 1–44, 71–77) in which the axostyle gradually disappears. Cutler (1919) said that in *D. termitis* the old axostyle does not disappear, and that, in a few cases, he found evidence of a longitudinal division. He (1920) believed that the axostyle of *Joenopsis polytricha* behaved in the same way but offers no facts in its support.

Dobell (1909) working upon *Eutrichomastix batrachorum* and *T. batrachorum* observed the absorption of the axostyle during the early phases of division, and believed that new axostyles were formed, when the body divides, by the division of the strand connecting the daughter blepharoplasts (*i.e.* the centrodesmose). Mackinnon (1910) held a similar view for the axostyle of *E. trichopterae*. Jollos (1911) gave a similar interpretation for the duplication of the axostyle in *Monocercomonas cetoniae*. Alexeieff's (1910) account of the absorption of the axostyle and the formation of two new ones from the centrodesmose in *E. motellae* is similar.

Martin and Robertson (1911) saw the solution of the old axostyle in trichomonads from fowls but did not discover how the new ones originated.

Kuczynski (1914, 1918), working upon a number of species of *Trichomonas*, gave a well-illustrated description of the formation of the new axostyles from the daughter blepharoplasts, the centrodesmose still persisting. This has been supported by the work of Wenrich (1921) and Grassé (1926). Hinshaw (1926) stated that, in *T. buccalis*, the outgrowth of the axostyle from the blepharoplasts might be delayed until after the division of the body.

The degree of affinity for iron haematoxylin varies in the axostyles of different species. Bělař (1916) demonstrated that, whereas the axostyles of *Monocercomonas* (= *Retortamonas*) *orthopterorum* develop, during division, as outgrowths from the blepharoplasts (as has been shown to occur in trichomonads), they differ from the trichomonad axostyle in their intensely siderophilic nature. Hinshaw (1926), however, found that the axostyle of *T. buccalis* was siderophilic and believed that, on this account, it is primitive. On this basis, supported by its similarity in derivation, he regarded it to be homologous with the flagella, and to be, in fact, an intracytoplasmic flagellum. From

similar considerations Alexeieff (1924) had previously advanced the same hypothesis. Kofoid and Swezy (1915) believed the axostyle to be motor in function and capable of vigorous lashings from side to side, such as has been described for the axostyle of *Pyrsonympha*. I have observed many living *T. batrachorum* for long periods but never saw any movement of the axostyle comparable with this. Wenyon (1907) held it to be an organ of temporary fixation, but this again I have been unable to verify. Dobell (1909, 1921) held the axostyle to be skeletal. From long observations upon cultures of *T. batrachorum* I have been unable to ascribe any particular function to the axostyle, but I am inclined to agree with Dobell's interpretation since the "trichomonad" form and the possession of an axostyle appear to be correlated.

Concerning the homology of the axostyle of trichomonads with similar structures in other groups the recent work on termites seems of interest. Koidzumi (1921) thought that in *Pyrsonympha* the axial filament functions as a blepharoplast for the flagellar cords, and that the axial filament of this subgenus is not homologous with the axostyle of trichomonads. In *Dinenympha* he found the arrangement similar. But Kirby (1924) found that in *Dinenympha fimbricata* new axostyles arise by outgrowth from the blepharoplasts, whose presence he demonstrated. In *Devescovina* and *Paradescovina* he (1926) found that the axostyles were similar in position and relation to the other organellae to the axostyle of Trichomonas. Powell (1928) has recently studied *Pyrsonympha* and has found distinct centroblepharoplasts, which function as division centres during mitosis and from which the daughter axostyles grow out as in *Trichomonas*.

The division of the nucleus. Kofoid and Swezy (1915) describe the formation of a spireme in the prophase in *T. augusta*, but they believe it to be of short duration. Kuczynski (1918) describes the chromatin, in the early prophase, as arranged in a faintly-staining network. I have occasionally seen a spireme in *T. batrachorum*, but so seldom that I cannot consider it to be an essential stage in the nuclear development.

In *T. batrachorum* I found six chromosomes. In *T. hominis* and the R.T. strain it has been much more difficult to count the chromosomes, but there appear to be five or six. In the prophase the chromosomes appear as large, separate granules differing amongst themselves in size. Wenyon (1907) found "usually six" chromosomes in *T. muris*; Wenrich (1921) in his detailed study of this species agrees with this. Dobell (1909) found six chromatin masses in *T. batrachorum*. The number which I have found in this species agrees with this. Martin and Robertson (1911) studying trichomonads in fowls believed that there were eight prophase chromosomes which are later reduced to four. Kuczynski (1914–1918) studying *T. muris*, *T. caviae*, *T. augusta*, and *T. batrachorum*, believed there to be eight prophase chromosomes which are reduced to four during the metaphase. Kofoid and Swezy (1915) described five chromosomes in *T. augusta*, *T. muris* and *E. serpentis*, and four in *Tetratrichomonas prowazeki*, and state that they are of unequal size. Cutler (1919) said

that the number of chromosomes in *D. termitis* appeared to be indefinite, between four and seven, but more usually six of equal size. Andrews (1925) described "about ten chromosomes" in *T. termopsidis*. Grassé (1926) counting at the equatorial plate said that in *T. batrachorum* he sometimes saw four and sometimes five chromosomes. He does not describe or illustrate the changes in the nucleus during the prophase, at which stage the chromosomes (in my experience) are counted most easily. The technique which he used, though demonstrating the parabasal body, renders the nucleus very different from its appearance when treated with other fixatives, and different from what one sees of its structure in the living animal. Becker (1926) studied division in *T. muris* var. *citelli* and his findings coincide with those of Wenrich. He obtained several good counts at the anaphase and found the number to be six. Tanabe (1925 *a*) found there to be six chromosomes in a trichomonad from the guinea-pig. In *E. serpentis* he (1926) found four chromosomes, and five in *T. eberthi*. Hinshaw (1926) found three chromosomes in *T. buccalis*. One would not expect the chromosomes to be the same in number in all species of *Trichomonas*, but discrepancies in number in the *same* species, when studied by different workers, need to be accounted for. The counting of such minute structures, often heaped upon one another, is an extremely difficult task, and a large amount of material is necessary. The cultivation of the species under investigation is an enormous help as it provides an inexhaustible supply of material rich in dividing forms. More detailed and careful study of some of the species is necessary before a definite statement upon the number of chromosomes can be made.

Kofoid and Swezy (1915) described in *T. augusta* and *T. muris* precocious longitudinal splitting of the chromosomes soon after they are formed in the prophase. A similar longitudinal splitting of the prophase chromosomes was observed by Kuczynski (1914, 1918), but according to his description these chromosomes coalesce to form four large chromosomes at the metaphase which split longitudinally to form the daughter chromosomes. Wenrich (1921) said that, in *T. muris*, in the prophase, each of the six chromosomes is formed of two halves closely associated, and these halves are drawn apart at the metaphase. He believed that where six single elements appeared in the prophase it was a result of bad fixation. Tanabe (1925) found a similar splitting of the prophase chromosomes in the *Trichomonas* from the guinea-pig. His account of the metaphase is not very clear, but, from his Figs. 9, 10 and 11, the halves of the chromosomes appear to fuse and the individual chromosomes to divide transversely on the equatorial plate, and not for the split chromosomes to pull apart as described by Wenrich. I have never seen anything approaching this precocious longitudinal splitting in any of the three trichomonads I have studied. The granules have always appeared at the prophase as single, well-defined units.

VIII. Summary.

1. Three trichomonads have been cultivated and studied, *T. hominis*, *Trichomonas* sp. from *M. nemestrinus* (= R.T. strain), and *T. batrachorum* from English frogs and toads.

2. A number of strains of *T. batrachorum* were cultivated over periods varying from two weeks to five months without the appearance of a *Eutrichomastix* stage.

3. The division process of *T. batrachorum* has been studied. The new basal fibre arises as an outgrowth from the blepharoplast. The old axostyle is absorbed and new ones are formed from the daughter blepharoplast during the telophase. Six chromosomes appear during the prophase. Spindle fibres do not appear. There is a separation of the daughter blepharoplasts into centrosome and basal granule at the metaphase.

4. Division of *T. hominis* and *Trichomonas* sp. from *M. nemestrinus* is essentially similar to that of *T. batrachorum*. The number of chromosomes appeared to be five or six. Double individuals were found in the cultures, and in *T. hominis* individuals containing four or six sets of organellae. Their significance is obscure.

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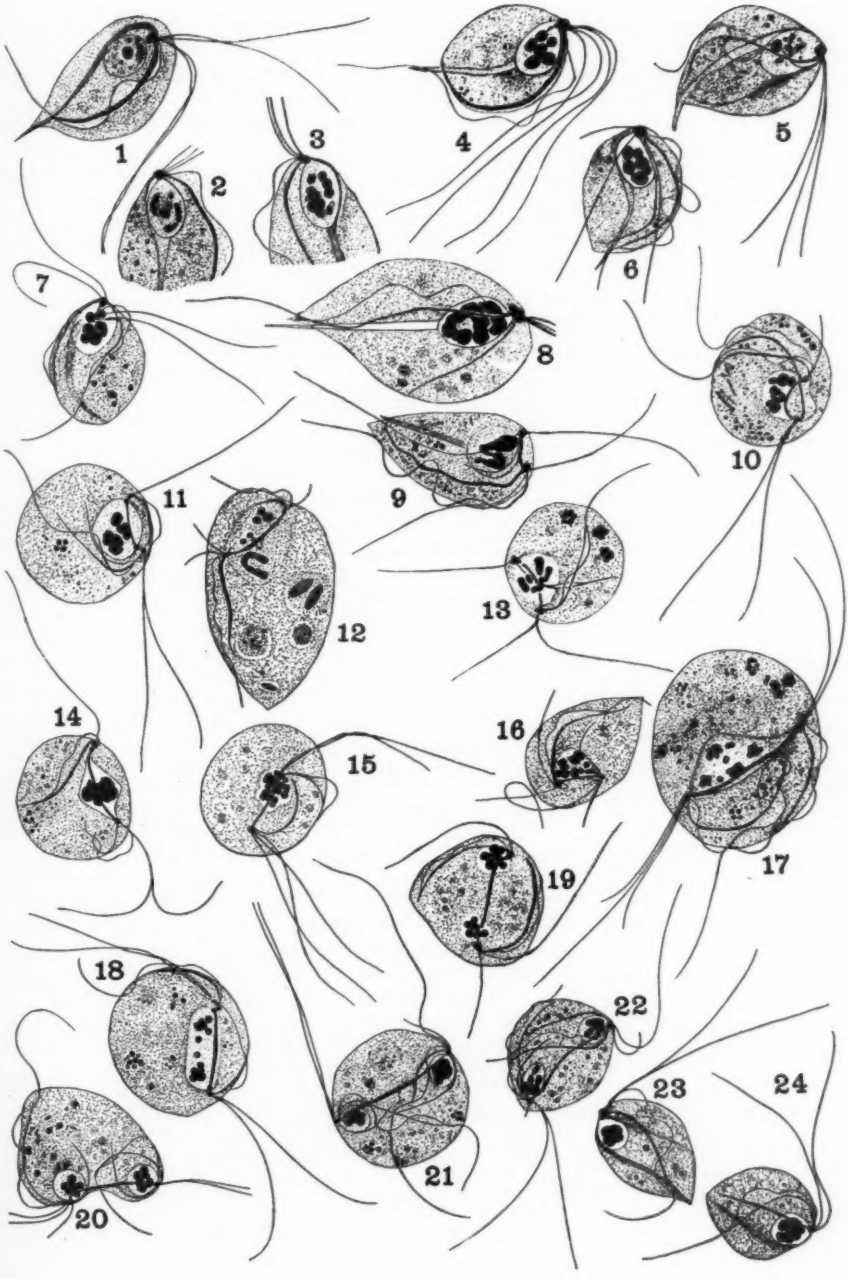
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DESCRIPTION OF PLATES VI AND VII.

All figures have been drawn with an Abbé camera lucida under a $\frac{1}{12}$″ fluorite oil immersion lens at an approximate table magnification of 3300 diameters. Plate VI has been reduced by $\frac{1}{3}$ in reproduction. In a number of figures the flagella have obviously been cut off.

PLATE VI.

Trichomonas batrachorum. (Figs. 1–24.)

Fig. 1. Normal individual in resting stage.
Fig. 2. Nucleus preparing for division, formation of extrakaryosomic granules.
Fig. 3. Further advanced than Fig. 2.
Fig. 4. Individual with nucleus containing six prophase chromosomes.
Fig. 5. Individual with new basal fibre. Nucleus contains irregular extrakaryosomic granules.
Fig. 6. Unequal division of the blepharoplast; new basal fibre, six unequal prophase chromosomes.
Fig. 7. Blepharoplasts moving apart, centrodesmose formed, new basal fibre and flagellum, six prophase chromosomes, axostyle disappearing.
Fig. 8. Giant with new basal fibre and nucleus containing a spireme.
Fig. 9. Individual with blepharoplasts apart, centrodesmose, new basal fibre little developed, nucleus in spireme.
Fig. 10. Nucleus preparing for equatorial plate, looped chromosomes.
Fig. 11. Six chromosomes; the blepharoplasts have divided to form basal granules and centrosomes. The delicacy of the original basal fibre is noticeable.
Fig. 12. Giant, spireme breaking up to form chromosomes.
Fig. 13. Elongated chromosomes.
Fig. 14. Equatorial plate.
Fig. 15. Metaphase, chromosomes dividing.
Fig. 16. Same.

Fig. 17. Giant. Possible longitudinal splitting of the chromosomes.
Fig. 18. Anaphase.
Fig. 19. Early telophase.
Fig. 20. Telophase. Formation of new axostyles from the blepharoplasts.
Fig. 21. Same.
Fig. 22. Later telophase.
Fig. 23. Daughter individual, centrodesmose almost disappeared, three flagella.
Fig. 24. Same, centrodesmose still quite plain, two flagella.

PLATE VII.

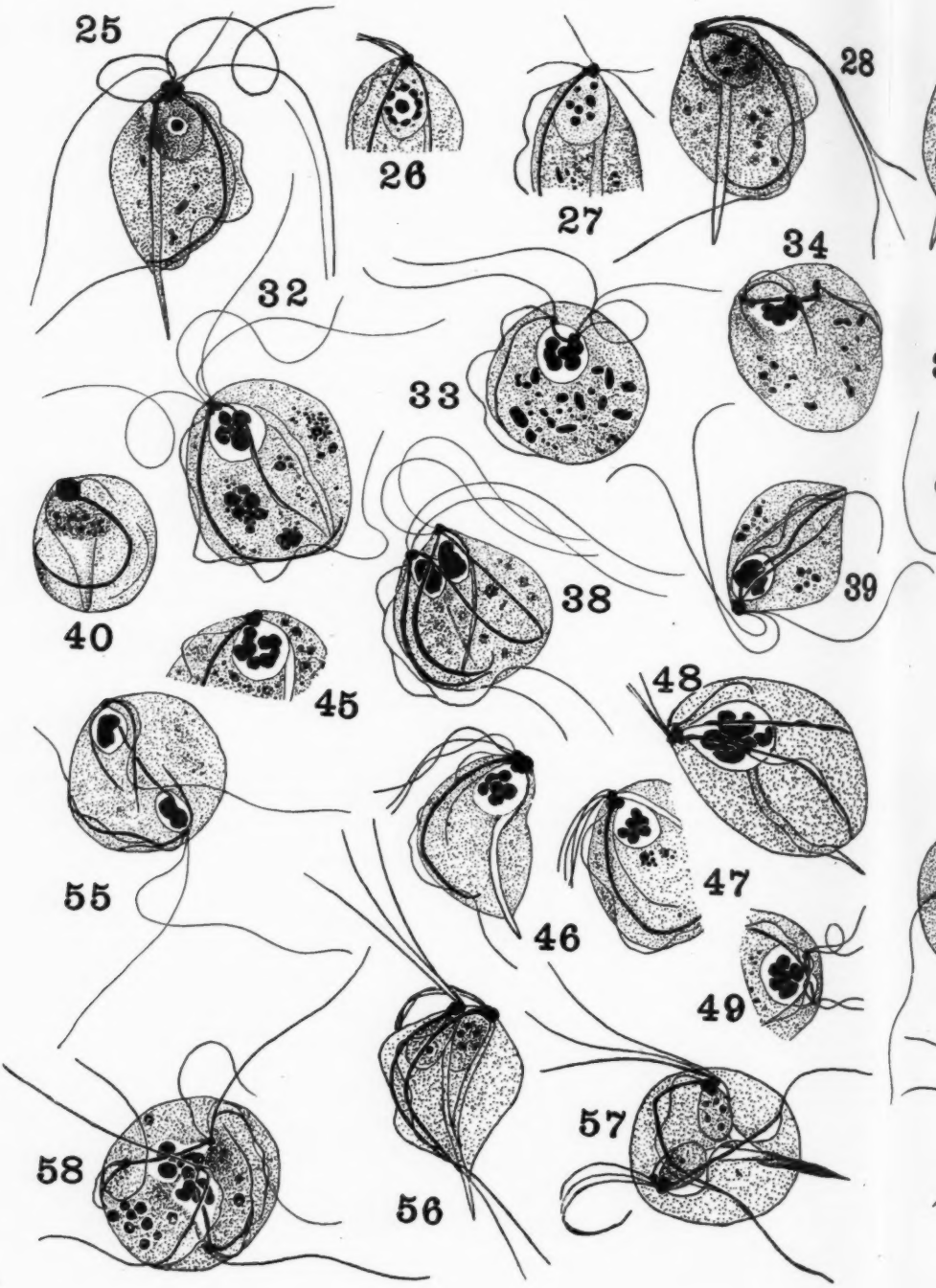
Trichomonas sp. from *Macacus nemestrinus*. (Figs. 25–40.)

Fig. 25. Individual with four flagella.
Fig. 26. Formation of extrakaryosomic granules.
Fig. 27. Small karyosome and definite granules.
Fig. 28. Individuals with three flagella, definite granules in nucleus.
Fig. 29. Same.
Fig. 30. Anterior end of giant, five or six prophase chromosomes, new basal fibre.
Fig. 31. Blepharoplast dividing, nucleus contains large granules. Formation of new basal fibre, membrane and flagellum.
Fig. 32. Same, axostyle disappearing.
Fig. 33. Daughter blepharoplasts moving apart.
Fig. 34. Daughter blepharoplasts have divided to form centrosomes and basal granules.
Fig. 35. Anaphase.
Fig. 36. Telophase; new axostyle forming at one end.
Fig. 37. Later telophase, formation of new axostyles at both ends.
Fig. 38. Stage in the formation of a double individual; centrodesmose looped.
Fig. 39. Daughter individual. Centrodesmose persisting.
Fig. 40. Rounded up individual.

Trichomonas hominis. (Figs. 41–60.)

Fig. 41. Individual with four flagella.
Fig. 42. Individual with three flagella.
Fig. 43. Anterior end showing three or four granules in blepharoplast.
Fig. 44. Formation of extrakaryosomic granules in the prophase.
Fig. 45. Later stage.
Fig. 46. New basal fibre, six ? chromosomes.
Fig. 47. Same; axostyle arising from lobed blepharoplast.
Fig. 48. Giant. Formation of new membrane and flagellum, degeneration of axostyle, chromatin on large blocks in nucleus.
Fig. 49. Anterior end. Separation of daughter blepharoplasts with two flagella each. Six ? chromosomes.
Fig. 50. Metaphase.
Fig. 51. Metaphase with rod-like chromosomes. Daughter blepharoplasts have divided into centrosomes and basal granules.
Fig. 52. Anaphase.
Fig. 53. Telophase.
Fig. 54. Later telophase showing early development of new axostyles.
Fig. 55. Later telophase.
Fig. 56. Double individual.
Fig. 57. Same, another position.
Fig. 58. Division of double individual.
Fig. 59. Same telophase.
Fig. 60. Individual containing six sets of organellae.

(*MS. received for publication* 25. XI. 1930.—Ed.)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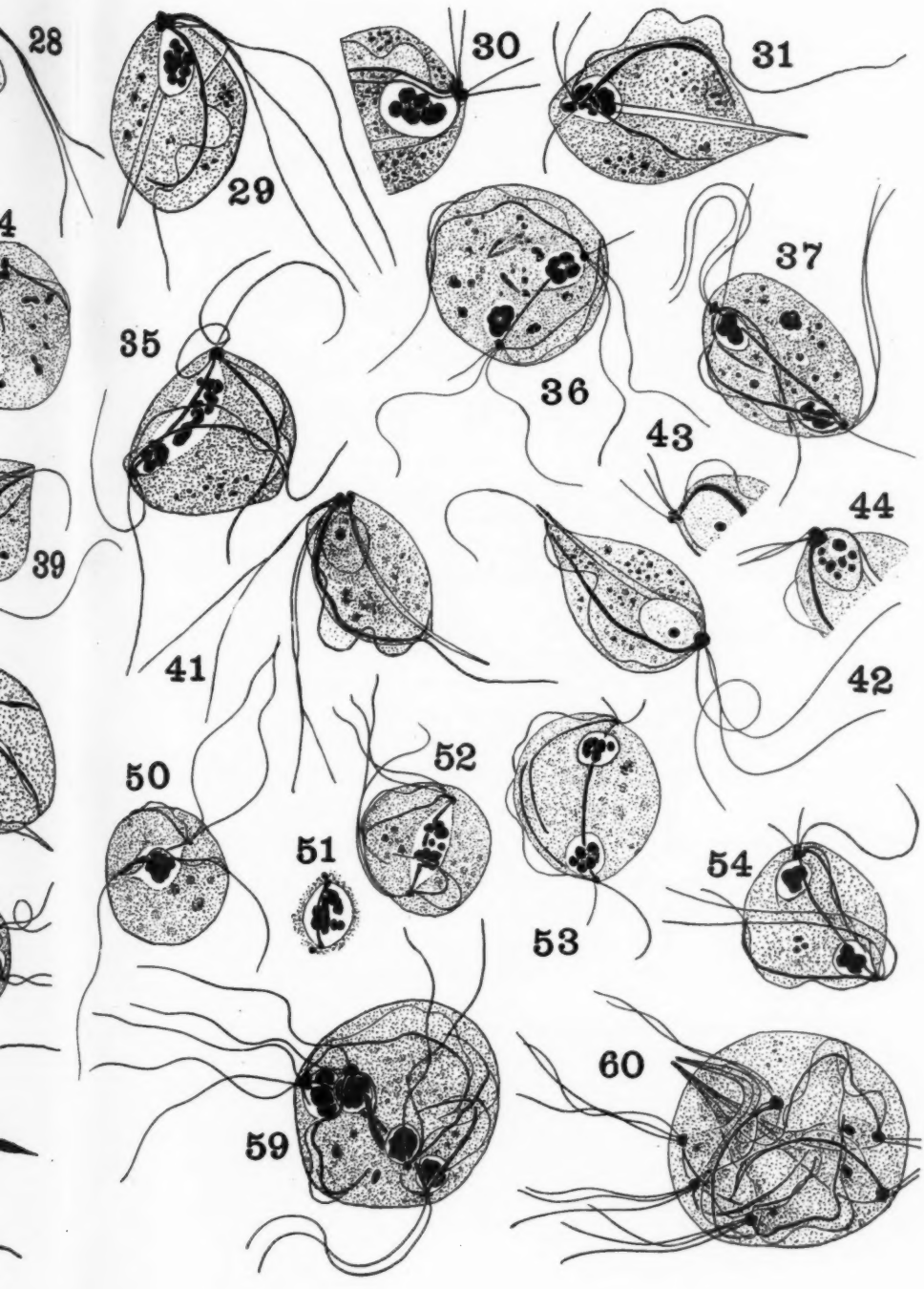
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A NEW GENUS (*SPINOMETRA*) OF THE FAMILY LEPODERMATIDAE ODHNER (TREMATODA) FROM A TORTOISE, WITH A SYSTEMATIC DISCUSSION AND CLASSIFICATION OF THE FAMILY.

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(With 6 Text-figures.)

LITTLE is known about the trematode fauna of India. Hitherto no species has been described from an Indian tortoise except *Polystomum kachugae* Stewart. In the present paper I describe a new genus *Spinometra* from a tortoise, and in the systematic account of the family Lepodermatidae I include new observations on other genera which I have studied and which I shall describe in subsequent papers.

Baer in 1924 split up the Lepodermatidae Odhner into two families, Reniferidae Baer and Lepodermatidae Odhner e.p. Baer. According to the latest views from Neuchâtel, Fuhrmann (1928) has dropped the Reniferidae and sub-families created by Baer, and has enlarged the family Lepodermatidae so as to include the Telorchiinae Looss in it. Considering that the classification of this family is in an unsettled condition, and that the latest attempts of Travassos (1928) have not much improved upon it, I have found it necessary to discuss the relationships of the various genera and give a more natural classification of this family.

Spinometra kachugae nov. gen., nov. spec.

The trematodes of this genus were collected by me in 1926 from the small intestine of *Kachuga dhongoka*, a tortoise commonly available in the Ganges at Allahabad. All the specimens, six in number, were obtained from one tortoise; of these I possess two in entire mounts and others in longitudinal and transverse sections.

The body (Fig. 1) is elongated, tapering towards the anterior end, becoming narrowest in the region of the pharynx and terminating in a blunt point. The size is small, measuring 9–12 mm. in length and 1·7 mm. in greatest breadth, which is attained in the region containing the ovary and receptaculum seminis. The posterior part of the body is narrow, measuring 0·75–0·86 mm. in breadth, and becomes rounded at the extreme end. In the region of the posterior testis the body measures 1·36 mm., while in that of the anterior testis it measures 1·6 mm. The colour is slightly greyish. The body in front of the anterior testis

is covered with scale-like chitinous spines which increase in number from behind forward. The spines are much more numerous near the anterior end, where they are arranged in rows; in the region of the cirrus sac their number is smaller, in that of the ovary they are still fewer and far separated, and in that of the anterior testis they are very scarce or nearly absent. They have a flat, semi-cycloid shape, with their free-pointed end directed outwards towards one side of the body, instead of being directed upwards as is usually the case.

The oral sucker is very small and has a circular outline, measuring 0·09–0·1 mm. It lies subterminally at the anterior end, with its opening directed towards the ventral surface. The ventral sucker is nearly circular, and measures 0·3–0·36 mm. in diameter. It is situated far anteriorly at a distance of only 1·6–2·2 mm. from the anterior end, *i.e.* about one-sixth of the length of the body from the anterior end. The ratio in the size of the two suckers is about 1 : 3. The prepharynx is small, being 0·008 mm. in length and 0·013 mm. in breadth. The muscular pharynx is more or less oval in outline, and measures 0·07–0·09 mm. by 0·05–0·06 mm. in size. It leads into a long narrow tubular oesophagus, 0·47–0·53 mm. long and 0·04 mm. broad, which bifurcates into the intestinal caeca far in front of the ventral sucker. The intestinal caeca reach a little in front of the posterior end of the body, and are provided throughout their course with small lobe-like outgrowths which are mainly present towards the outside. Behind the testes the caeca are not visible in entire mounts, as they are entirely covered by the enormous mass of uterine coils in this region. They occupy a position nearer the body wall than the median line of the body.

The excretory pore situated terminally at the posterior end is surrounded by a group of fairly large parenchymatous cells containing prominent nuclei. It leads into an elongated Y-shaped excretory bladder, occupying a median position and extending as far forward as the anterior testis, where it divides into two diverticula which, however, could not be traced on account of numerous uterine coils. The main stem is provided with a fairly large number of broad ramified lateral branches, which extend outwards in between the coils. They are distinctly seen in longitudinal sections in the hinder part of the body, possessing the same breadth near their origin as the bladder. The lateral branches are, however, not seen in front of the posterior testis.

The genital opening lies towards the left, closely in front of the ventral sucker, nearer the latter than the body wall. The reproductive organs, except the main mass of uterine coils and the posterior testis, lie in the anterior half

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Fig. 1. Dorsal view of *Spinometra kachugae* n.sp.

Lettering to Figs. 1–5. *b.w.* body wall; *c.* cirrus; *c.s.* cirrus sac; *ex.bl.* excretory bladder; *g.o.* genital opening; *i.c.* intestinal caecum; *l.t.* left testis; *L.c.* Laurer's canal; *m.* metraterm; *oes.* oesophagus; *o.s.* oral sucker; *oo.* ootype; *ov.* ovary; *ovi.* oviduct; *p.* parenchyma; *p.g.* prostate gland cells; *p.p.* pars prostatica; *r.s.* receptaculum seminis; *r.t.* right testis; *sp.* spines; *sp.c.* spines on cirrus; *s.g.* shell gland; *t.v.d.* transverse vitelline duct; *ut.* uterus; *vit.* vitellaria; *v.s.* ventral sucker; *v.sm.* vesicula seminalis; *v.r.* vitelline reservoir; *w.c.s.* walls of cirrus sac.

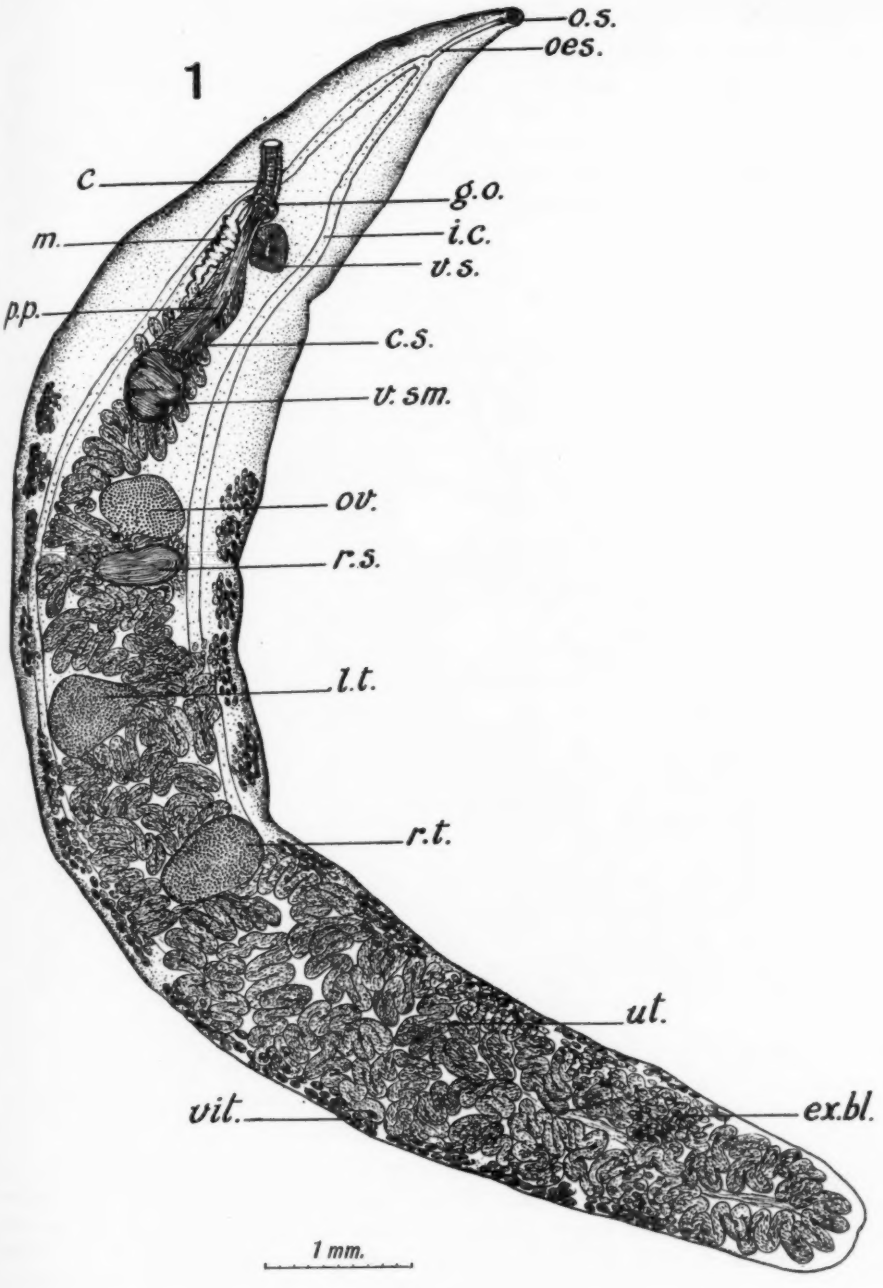

Fig. 1.

of the body. The testes lie more or less obliquely, one behind the other, separated by a distance of 0·9–1 mm. The anterior testis generally occupies a position to the left side, being separated from the left body margin by the follicles of the left vitellarium; it may sometimes, however, occupy a median position between the two vitellaria. It is somewhat elliptical or pear-shaped in form with entire margins, and measures 0·5–0·8 mm. in length, and 0·6–

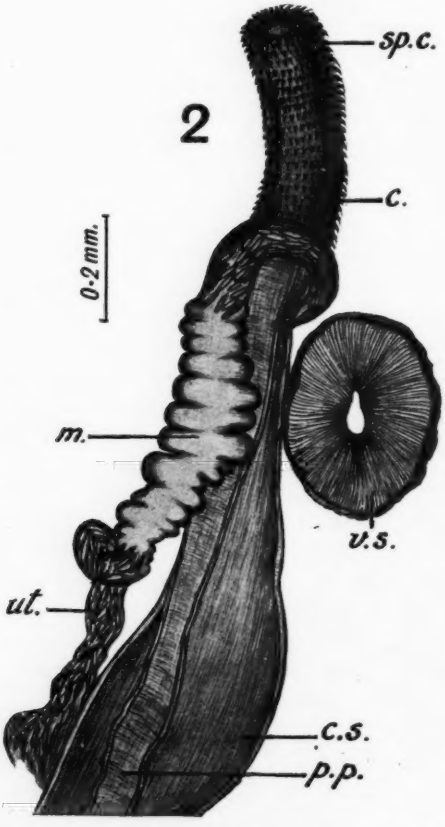

Fig. 2. Terminal part of cirrus sac with its contained organs and metraterm of the specimen drawn in Fig. 1, highly magnified. (For lettering *see* Fig. 1.)

0·9 mm. in maximum breadth. The vas efferent duct, which arises anteriorly near its outer margin, runs straight for a considerable length and becomes slightly twisted before entering the cirrus sac. The posterior testis has also entire margins, and is situated more towards the right, having a more or less ovoid shape and measuring 0·5–0·72 mm. in length and 0·6–1 mm. in maximum breadth.

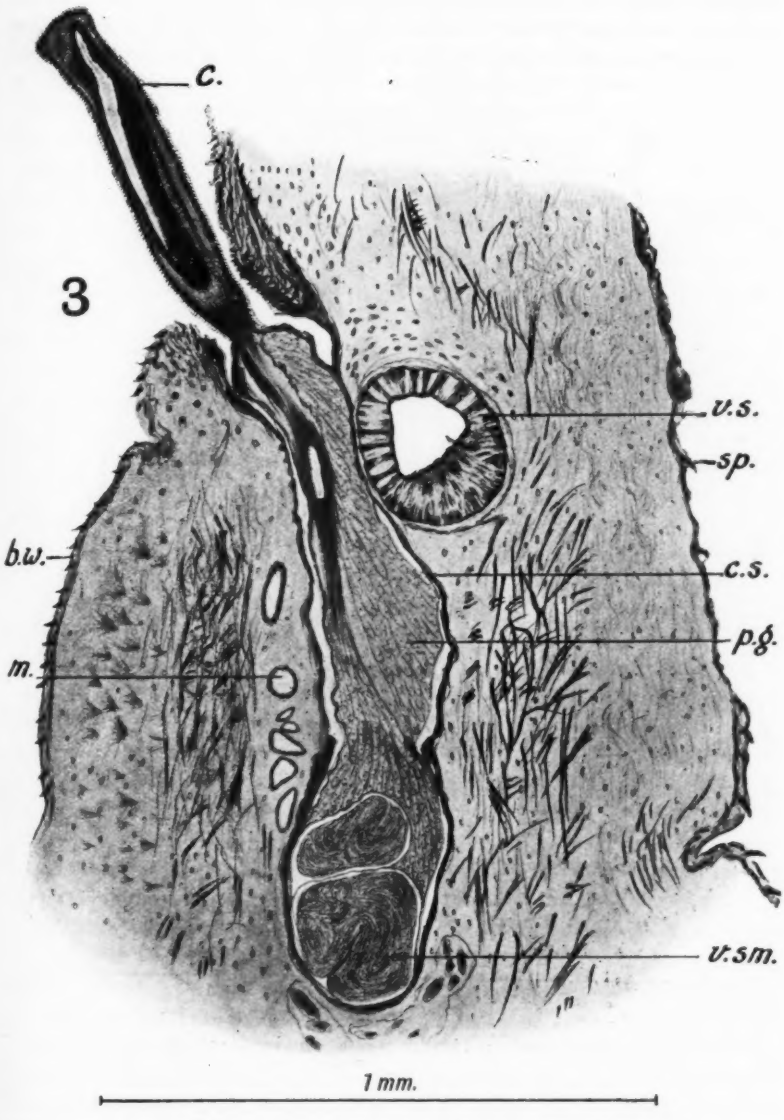

Fig. 3. Part of horizonto-longitudinal section showing structure of cirrus sac with its contained organs. (For lettering *see* Fig. 1.)

The cirrus sac (Figs. 1–4) is very large, more or less straight, having an elongated pear-shaped or conical form with a slight curvature, but in no way semilunar in shape. It is 1·69 mm. long and 0·4 mm. broad in its greatest diameter in the region a little above its base. It extends far behind the ventral

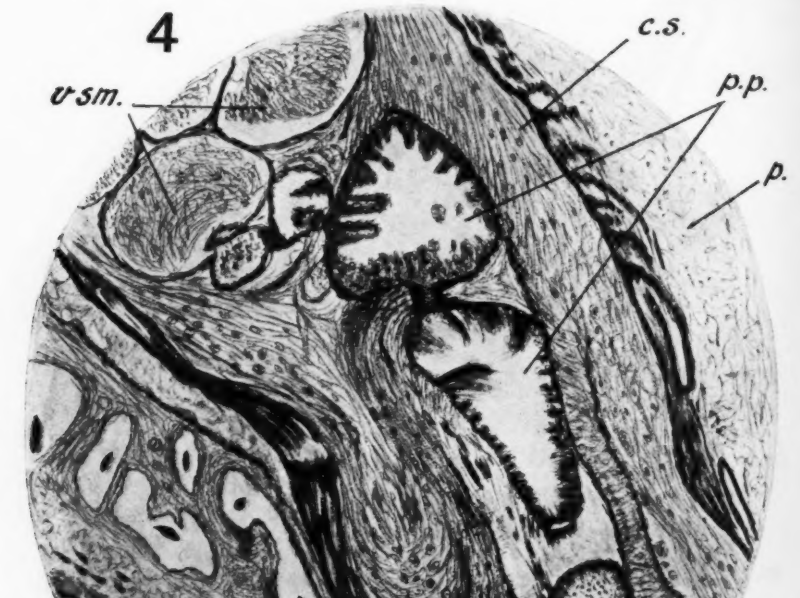

Fig. 4. Part of the section, highly magnified, showing a part of cirrus sac with vesicula seminalis and pars prostatica. (For lettering *see* Fig. 1.)

sucker, reaching nearly to the ovary; it consists of a long saccular and a small narrow tubular portion, lying adjacent to the left side of the ventral sucker, measuring 0·12–0·14 mm. in diameter, and sometimes becoming swollen before it opens into the genital atrium, the swollen portion measuring 0·16 mm. in diameter. The walls of the cirrus sac are highly muscular, and consist of an

outer thick layer of longitudinal and inner thin layer of circular muscle fibres. Its basal saccular portion, about 0·4–0·6 mm. in length, is entirely occupied by a large convoluted vesicula seminalis filled with sperms. The walls of the latter are thin, consisting only of a fine layer of longitudinal muscle fibres, the epithelial layer being absent. The vesicula seminalis passes by a narrow muscular constriction into the long pars prostatica 0·64–0·81 mm. in length, with a fairly broad lumen. The pars prostatica runs nearer the left side of the cirrus sac, and is broader proximally. Its wall is composed of circularly arranged muscle fibres, the epithelial lining having more or less entirely disappeared on account of the flow of the prostatic secretion through it. The prostate gland cells form a huge mass, occupying the entire space between the pars prostatica and the walls of the cirrus sac. In this mass are found a number of fine muscular strands, which attach the terminal part of the vas efferent duct to the walls of the cirrus sac. This mass presents a nodular appearance, lying towards the left side on account of the left-handed position of the pars prostatica. The latter passes imperceptibly into the ejaculatory duct 0·17 mm. in length. The cirrus is long and protrusible. When protruded it is seen to be continuous with, though somewhat constricted off from, the terminal portion of the cirrus sac, which lies within the genital atrium. It is an elongated, strong cylindrical organ, slightly arched on one side and concave on the other, measuring 0·4–0·6 mm. in length and 0·12–0·16 mm. in breadth, and entirely covered with spines.

The gonads occupy the usual position typical of the family, *i.e.* the ovary lies to the right, the anterior testis to the left or the same side as the genital opening, and the posterior testis to the right or the same side as the ovary. The ovary lies in the median line or somewhat to the right in front of the testes at a distance of 0·2–0·36 mm. behind the cirrus sac. It is more or less ovoid in shape, measuring 0·35 by 0·38 mm., 0·59 by 0·43 mm. and 0·6 by 0·4 mm. in size in the three specimens examined for the purpose. The oviduct, 0·017 mm. in diameter, originates from its inner margin near the posterior end and, after running a short distance inwards, joins the duct of the receptaculum seminis on one side and immediately after the yolk reservoir on the other to form the ootype, which is surrounded by the shell gland cells (Fig. 5).

The receptaculum seminis is more or less of an ovoid shape, and lies median or to the right side of the median line, closely behind the ovary, measuring 0·28–0·48 mm. in length and 0·28–0·7 mm. in maximum breadth. It is filled as usual with sperms, and communicates by a small narrow duct with the ootype, the duct arising from its anterior margin near the outer side. The epithelial lining of the receptaculum seminis is absent in mature specimens. The Laurer's canal arises from the duct of the receptaculum seminis. It is a long coiled tube, 0·027–0·029 mm. in thickness, taking a backward course for some distance and then turning towards the dorsal surface to open to the exterior by a minute pore in the mid-dorsal line, the pore being lined by cuticle continuous with that of the body wall. Its epithelium is surrounded by a

fairly thick layer of circular muscle fibres arranged in narrow bands. The shell glands are large cells of the usual type arranged radially around the ootype; they have a conical form with a broad outer end, each containing a nucleus surrounded by basophil granular cytoplasm and a long narrow tubular portion which, before entering the wall of the ootype, becomes dilated to form a small

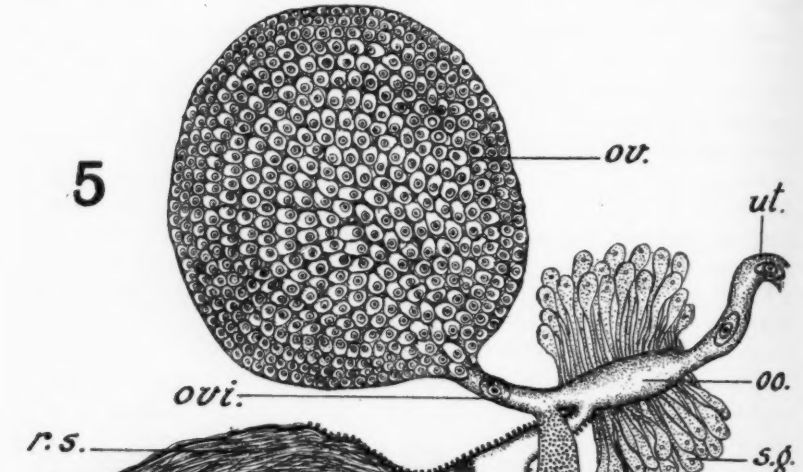

Fig. 5. Semi-diagrammatic view of female sexual organs constructed from a series of longitudinal sections. (For lettering *see* Fig. 1.)

pear-shaped reservoir filled with a secretion giving the characteristic mucin reaction when stained with haematin or haematoxylin. The shell gland complex occupies a median position behind and inside the ovary. The ootype is about twice as broad as the oviduct, measuring 0·024 mm. in diameter; it passes backwards, turning to the right into a convoluted mass of uterus which fills more or less completely the posterior half of the body, especially in the region behind the posterior testis, in which the descending and ascending convolutions are placed more or less distinctly apart in a regular manner to

the right and left sides. As the uterus winds its way backwards between the two testes into the posterior part of the body to return forwards by the same way, the convolutions make a characteristic S-shaped twist, which can be clearly noticed between the ovary and the two testes. It ends in the metraterm, which extends behind the ventral sucker and opens externally in the genital atrium. The metraterm is situated to the left, close to the terminal part of the cirrus sac, which it may, to a certain extent, cover dorsally. It is more or less straight for a great part of its length, or somewhat crescent-shaped with a characteristic folded appearance presented by its walls; it measures 0·5–0·8 mm. in length and 0·18–0·4 mm. in maximum breadth. Its small terminal portion possesses thin smooth walls, and has a narrow lumen which is generally filled with ova. For a great part of its length the metraterm is lined with glandular epithelium covered by a thick wall of powerful circular muscle fibres arranged in bands, which is surrounded again by a thin layer of longitudinal muscle fibres. Both the epithelium and circular layer of muscle fibres are folded, and present the characteristic appearance mentioned above. The parenchyma outside the metraterm becomes concentrated to provide an outer sheath, which serves more or less as a supporting tissue. Also present in this tissue are a large number of gland cells which probably pour out their secretion into the epithelial layer of the metraterm, the latter losing its cellular structure in advanced sexual maturity. The eggs are elliptical, having a thin brownish shell, and measure 0·034 mm. by 0·013 mm. in size.

The vitellaria occupy the lateral areas near the body wall, beginning in the region of the hinder end of the cirrus sac and terminating 1–0·8 mm. in front of the posterior end of the body. They never extend behind the blind end of the intestinal caeca, and are confined to the dorsal and ventral surfaces of the body, lying partly to the outer side of the caeca and partly overlapping them. Each gland consists of ten to fourteen groups of ovoid or conical follicles. The posterior groups are generally larger, consisting of a greater number of follicles than the anterior ones, and are so closely situated as to become fused. The transverse vitelline duct of each side leaves the gland at the level of the posterior margin of the seminal receptacle, and runs inwards transversely to open into a prominent vitelline reservoir.

The genus *Spinometra* seems to be closely related to *Glossidiella* Trav., from which it is sharply separated on account of the shape of its body, presence of a long narrow oesophagus and a very small oral sucker, position of the genital pore (lateral near acetabulum in *Glossidiella*, but lateral closely in front of acetabulum in *Spinometra*), shape of the cirrus sac and the cirrus covered with spines. It is also distinguished by the position of the vitellaria which, in *Glossidiella*, extend mesially near the median line. The hosts are also different, the latter genus being parasitic in the lungs of the snake *Cyclagras gigas* in South America.

Diagnosis of the genus Spinometra.

Body elongated, tapering anteriorly to a point; oral sucker very small; ventral sucker situated far anteriorly at about one-sixth of the distance from anterior end; ratio in size of the suckers 1:3. Prepharynx and pharynx present; oesophagus long and narrow; intestinal bifurcation much in front of ventral sucker; intestinal caeca with small blind diverticula reaching a little in front of hinder end. Genital opening immediately in front of ventral sucker to the left side. Testes large, elliptical or ovoid; anterior testis lying to the left, or sometimes median, in anterior half of the body; posterior testis situated more towards the right, rarely median, just behind first half of the body. Ovary median or a little to the right in front of testes and a little behind cirrus sac. Receptaculum seminis and Laurer's canal well developed. Vitellaria laterally situated from hinder end of cirrus sac to a small distance in front of posterior end of body. Cirrus sac very large, highly muscular and somewhat conical, with its long axis parallel to the length of the body, and extending far behind the ventral sucker, nearly reaching ovary. Vesicula seminalis large and convoluted, occupying the basal portion of cirrus sac and passing by a constriction into a long tubular pars prostatica; prostate gland cells forming an enormous mass. Cirrus stout and long, covered with spines. Uterus winding backwards between testes into posterior part of body and returning forwards by the same way, descending and ascending convolutions placed more or less distinctly apart to the right and left sides. Metraterm well developed, having a muscular folded wall. Excretory bladder Y-shaped with a long stem provided with somewhat ramified lateral branches and dividing near anterior testis into two cornua. Ova elliptical, measuring 0·034 by 0·013 mm. in size. Host: *Kachuga dhongoka*. Locality: Allahabad, India.

Nomenclature of the family Lepodermatidae Odhner.

The nomenclature of the family has been recently discussed by Poche (1925) who, after discussing the nomenclature of the most central and typical genus *Lepoderma* Looss syn. *Plagiorchis* Lühe, prefers the latter name for the genus and Plagiorchidae Lühe for the family. Lühe published the name of his genus *Plagiorchis*, including two species *Dist. reniferum* Lss. and *Dist. horridum* Leidy in it, on December 28, 1899. Looss published the account of his genus *Lepoderma* with the type species *L. ramlianum* Lss. and his sub-family Lepodermatinae on the same date, but the journal was issued from the press on December 30, 1899. Braun, who first pointed out the synonymy of these genera as well as that of *Prosthogonimus* Lühe with *Prymnoprion* Lss., on account of the priority by one day of the "Versendungsdatum"[1] of Lühe's work, accepted the names used by Lühe. Stiles also in 1901 adopted Lühe's denominations, giving preference to the date of issue. But Looss had pointed

[1] Date of posting.

out that Lühe, while indicating the characters of his genus, had omitted to designate a genotype. Odhner in 1911 gave priority to the name *Lepoderma*, because it was bound up with the type species *L. ramlianum*, whereas *Dist. reniferum* and *Dist. horridum*, which first appeared with *Plagiorchis*, were found to belong to the genera *Astiotrema* Lss. and *Styphlodora* Lss. respectively. More recently Fuhrmann (1928) obviously follows Braun, Stiles and Poche in taking "Versendungsdatum" to settle the controversy. I prefer the name *Lepoderma*, considering it arbitrary to attach importance to the date of issue of the journal from the press. Apart from the question of the nomenclature of the genus, the sub-family name Lepodermatinae Lss. to which this genus certainly belongs appeared in 1899, whereas its synonym Plagiorchinae Lühe appeared in 1901. As the sub-family was raised to the rank of the family Lepodermatidae by Odhner, who first gave its diagnosis and discussed the relationships of the genera assigned to it, it appears necessary to establish the name *Lepoderma* for the genus and Lepodermatidae for the family. Baer in 1924 also tacitly accepted these names.

Systematic discussion and classification of the Lepodermatidae Odhner.

The family Lepodermatidae is the largest of the digenetic trematodes. Looss (1899) considered it as sub-family Lepodermatinae. Odhner (1911) gave a careful account of the Lepodermatinae Lss. and included it in his new family Lepodermatidae, which he constituted by adding to it a large number of other genera, the systematic position of which was uncertain. Baer split up this family into two families, Lepodermatidae Odhner e.p. Baer and Reniferidae Pratt e.p. Baer, on the basis of the absence or presence of the lateral branches of the excretory bladder. Poche (1925) criticised the creation of the Reniferidae, emphasising that the totality of all morphological characters must be taken into account for each natural classification. Fuhrmann (1928) has dropped Baer's families and sub-families following Odhner's denunciation. Travassos (1928) gives a tentative classification, but there is no indication of the characters on which it is based. His sub-family Lepodermatinae, which he divides into four sections, comprises the genera of all the five sub-families, *i.e.* Lepodermatinae Lss., Astiotreminae Baer, Styphlotreminae Baer, Cymatocarpinae Baer and Enodiotreminae Baer. He has included *Encyclometra* in the Reniferinae Pratt and *Cymatocarpus* in the Brachycoeliinae Lss. My discussion of the relationships of the genera will show that this classification is unnatural and needs modification.

There is no doubt that the family Reniferidae Baer is untenable, and must be dropped. The importance of the excretory system is being carried too far when we see a new family created only on account of the presence of lateral branches in the excretory bladder. Of all the systems the excretory system is the most constant, but the component parts, which show constancy, are the shape of the bladder, position, number and arrangement of accessory collecting

tubes, capillaries and flame cells. As these are not found to be different in any member of the Reniferidae, there is little justification for creating this family. The lateral branches of the excretory bladder differ in their number, arrangement and distribution in *Styphlodora*, *Styphlotrema*, *Pachypsolus* and *Enodiotrema*. They do not indicate that constancy of a morphological character, which we should consider to have been evolved in some regular manner: on the other hand they appear to have arisen independently, due to convergence or specialisation, just in the same way as the blind caeca or outgrowths have arisen from the intestinal caeca in the various distome trematodes. Moreover, it is difficult to imagine how closely related genera such as *Pneumatophilus*, in which the lateral branches are absent, and *Renifer*, *Ochetosoma* and *Lechriorchis* in which they are present, can be assigned to two different families.

There is no doubt that *Lepoderma* is the most typical genus occupying a central position in the family. The genera *Haplometroides* and *Haplometra* are closely related to it and are derived from it along one line of evolution, the former occupying an intermediate position between the two. *Haplometroides* resembles *Haplometra* in general form of the body, topography of organs, small size of the limbs of the Y-shaped excretory bladder, right-sided position of the ovary, position and shape of the cirrus sac and structure of the organs contained within the latter; while in the oblique position of the testes and arrangement of uterine coils it resembles *Lepoderma*. It, however, differs from both in smaller length of the intestinal caeca, more lateral position of the genital pore, presence of the receptaculum seminis, and relatively feeble development of the vitellaria, which are composed of more or less distinct follicles arranged in five groups.

From *Haplometroides* we can derive the genus *Tremiorchis* by further reduction of the cornua of the excretory bladder and length of the intestinal caeca. The vitellaria in both these genera are of about the same dimensions, and are composed of distinct follicles arranged in groups. The genital pore in *Tremiorchis* retains its primitive position, *i.e.* near median line close in front of the ventral sucker. The topography of organs is very similar. The cirrus sac is half-moon shaped and the vesicula seminalis straight and tubular in both. From *Tremiorchis* we can derive *Brachycoelium* with an elongated cylindrical excretory bladder, the anterior diverticula of which are reduced to small pockets. The posterior testis in *Brachycoelium* has moved forwards so as to lie at the same level with the anterior testis; in other respects, however, the two genera resemble each other more or less closely. *Margeana californiensis* Cort, as pointed out by Miller (1930), belongs to the genus *Glypthelmins* as *G. californiensis*, and should therefore no longer be included in the sub-family Brachycoeliinae. Travassos is right in including the genus *Cymatocarpus* in the Brachycoeliinae, to which I also assign the genus *Leptophallus*, though it shows certain striking peculiarities indicating its aberrant nature. It resembles *Brachycoelium* in possessing both testes at the same level, genital openings (genital sinus absent) slightly to the left, close in front of ventral sucker, Y-shaped excretory bladder

with two very small anterior lobes, small intestinal caeca extending up to the middle of the body, and vitellaria occupying an anterior position. Its aberrant nature is strikingly indicated by the presence of a great part of the vesicula seminalis outside the cirrus sac, absence of the receptaculum seminis and peculiar course of the uterine convolutions.

Sub-family *Brachycoeliinae* Looss.

Testes situated at the same level in front of middle of body, genital pore almost median, close in front of ventral sucker, cirrus sac to right side of ventral sucker, vesicula seminalis straight, receptaculum seminis present except in *Leptophallus*, vitellaria not extending behind middle of body, posterior half entirely occupied by uterine coils. Found in intestines of Amphibia, Reptilia and Fishes.

Haplometra resembles *Lepoderma* almost completely in the digestive system, excretory system except in size of the cornua of the bladder, position of the genital pore, position and structure of the cirrus sac and vesicula seminalis, presence of well-developed cirrus, position of the ovary to right side of the posterior end of cirrus sac, and in absence of the receptaculum seminis. The points of difference are general shape of the body and tandem position of the testes in *Haplometra*, in consequence of which the ascending and descending uterine convolutions instead of passing between the testes as in *Lepoderma* extend ventrally behind them except one descending convolution, which is pressed between them towards the dorsal side. *Haplometra cylindracea* (Zed.) is found in the lungs of *Rana temporaria*. The view that the distomes living in the lungs are descended from those living in the gut seems to be quite sound. The distomes first appeared as intestinal parasites; later on some species migrated towards the mouth cavity and thence through the trachea into the lungs. *Haplometroides*, which was obtained from the mouth of a South American elaps, shows how a *Lepoderma*-like form living in the gut first migrated towards the mouth cavity. The relationships of the genera *Saphedera* and *Pneumonoeces* with *Haplometra* have been discussed by Looss (1899) and Odhner (1911). The genera *Saphedera*, *Pneumonoeces* and *Pneumobites* are closely related to one another on account of the position of the genital opening at the base of the pharynx to the right or left side, and presence of a very long cylindrical and somewhat coiled cirrus sac. In *Saphedera* both the genital pore and ventral sucker have shifted forwards together, in *Pneumonoeces* and *Pneumobites* the ventral sucker, which is far separated from the genital pore, has returned secondarily to its more posterior position. *Saphedera* occupies an intermediate position between *Haplometra* on the one hand and *Pneumonoeces* and *Pneumobites* on the other. It resembles the former in the presence of a Laurer's canal and absence of a receptaculum seminis, whereas *Pneumonoeces* and *Pneumobites* possess a well-developed receptaculum seminis and lack a Laurer's canal.

The genera *Astiotrema* and *Glypthelmins* are closely related to *Lepoderma*, from which they mainly differ in the shape of the cirrus sac, small size of the cirrus and presence of the receptaculum seminis. The cirrus sac in *Astiotrema*

extends far behind the ventral sucker. I include *Lepoderma*, *Glypthelmins*, *Astiotrema*, *Haplometroides*, *Tremiorchis*, *Haplometra*, *Rudolphiella* and *Opisthioglyphe* in the sub-family Lepodermatinae Lss. and accept Saphederinae Baer for *Saphedera*, *Pneumonoeces* and *Pneumobites*.

Sub-family *Lepodermatinae* Looss.

Excretory bladder Y-shaped or cylindrical, cirrus sac typically half-moon shaped except in *Opisthioglyphe endoloba* (Duj.), genital opening median or slightly to the left or right, close in front of ventral sucker, testes situated obliquely or in tandem, cirrus present, vesicula seminalis straight and pars prostatica short. Found in intestines of Amphibia, Reptilia and birds and in lungs of Amphibia.

Sub-family *Saphederinae* Baer.

Body much elongated, genital pore situated at the base of pharynx, cirrus sac very long, cylindrical and somewhat coiled, testes parallel, nearly symmetrically situated, one slightly in front of the other, except in *Saphedera* in which they are tandem, vitellaria feebly developed and composed of follicles arranged in grape-like bunches, Laurer's canal present or absent. Found in lungs of Amphibia and Reptilia.

The genus *Styphlodora* also resembles *Lepoderma* closely in the topography of its organs, alimentary system (intestinal caeca in *S. najae* Nicoll are longer than in other species, reaching near the hinder end as in *Lepoderma*), median position of the genital pore immediately in front of ventral sucker, oblique position of the testes, semilunar shape of the cirrus sac, bent closely round the right side of the ventral sucker, and presence of a long cylindrical cirrus. *S. najae* occupies an intermediate position between *Lepoderma* and *Styphlodora* as is indicated by the length of its intestinal caeca, arrangement of uterine coils, short pars prostatica and long cirrus. *Styphlodora bascaniensis* Goldberger (1911) must be removed from the genus *Styphlodora*, from which it differs in such important points as the position of the genital pore, which lies median or slightly to the right, close behind the intestinal bifurcation, thin-walled cylindrical and slightly curved cirrus sac, situated somewhat dorso-laterally to the acetabulum with its base terminating in front of the hinder margin of the latter, stronger development of the vitellaria, Laurer's canal ending in a blind globular end, and absence of lateral branches in the excretory bladder. This species resembles *Styphlotrema solitaria* in the length of its intestinal caeca, slightly symmetrical position of the testes and having well-developed vitellaria, but it differs in the position of the genital pore, position and shape of the cirrus sac, size and shape of the pars prostatica, Laurer's canal ending blindly, position of the vitellaria, arrangement of uterine coils and absence of lateral branches in the excretory bladder. I create a new genus *Platymetra* to include *S. bascaniensis*, and consider it closely related to *Mediorima* Nicoll, which it resembles in the genital pore situated close behind the intestinal bifurcation, and the cirrus sac not reaching the posterior margin of the ventral sucker. *Platymetra* should be included as an aberrant genus in the sub-family Reniferinae Pratt. The biological fact of its occurrence in the liver

of *Bascanion constrictor*, Virginia, U.S.A., also points to its possessing affinities to the genera of this sub-family.

I am inclined to believe that *Styphlodora* represents the origin of one side branch of the main stem as indicated by the typical genus *Lepoderma*, and *Haplometroides* or *Tremiorchis* as that of the other. In the line beginning at *Styphlodora* the vesicula seminalis is curled and confined to the basal part of the cirrus sac, while the pars prostatica is long and tubular except in *Dasymetra*, where the pars prostatica is small and bulbular and ductus ejaculatorius long; in the line representing the sub-families Lepodermatinae, Saphederinae and Brachycoeliinae the vesicula seminalis is straight and large and the pars prostatica much smaller. *Styphlodora*, *Styphlotrema*, *Pachypsolus*, *Glossidium*, *Glossidiella* and *Spinometra* are assigned to the sub-family Styphlotreminae Baer.

Sub-family *Styphlotreminae* Baer.

Genital pore median, slightly to the right or left immediately in front of ventral sucker, cirrus sac of considerable length, more or less curved, situated adjacent to ventral sucker and extending behind it as far as the ovary, descending and ascending uterine convolutions transversely arranged and set apart more or less regularly in right and left parts of body, muscular metraterm present, vesicula seminalis coiled and confined to basal part of cirrus sac, pars prostatica long and tubular and cirrus well developed. Found in the gut of tortoises, lizards and snakes and lungs of snakes.

The genus *Styphlodora*, found in the gut of lizards and snakes, shows the primitive habitat. Not only do we derive from *Styphlodora* the genera which constitute the Styphlotreminae, but we also derive from it the genera *Renifer*, *Lechriorchis*, *Zeugorchis*, *Ochetosoma*, *Pneumatophilus*, *Xenopharynx*, *Mediorima*, *Dasymetra*, *Platymetra* and *Stomatrema*, which constitute the sub-family Reniferinae.

Sub-family *Reniferinae* Pratt.

Intestinal caeca relatively small, ending about middle of body except in *Platymetra*, *Dasymetra*, *Stomatrema* and *Xenopharynx*, genital opening much lateral and in front of ventral sucker at level with pharynx near right or left body margin except in *Mediorima*, *Dasymetra*, *Stomatrema*, *Platymetra* and *Xenopharynx*, in which it is median behind or on the intestinal bifurcation, cirrus sac having a somewhat lengthened and curved shape and not extending behind the centrum of ventral sucker, receptaculum seminis absent except in *Platymetra*, *Stomatrema* and *Xenopharynx*, uterine coils having a more or less characteristic course, vesicula seminalis coiled, occupying basal part of cirrus sac, pars prostatica long and tubular except in *Dasymetra*, testes nearly symmetrically situated at the same level except in *Mediorima*, *Dasymetra* and *Xenopharynx*, in which posterior testis lies a little further back. Found in the mouth cavity, lungs, oesophagus, intestine, ventricle, bile duct, gall bladder and liver of snakes.

Mediorima shows a primitive habitat, being parasitic in the gut of *Tropidonotus ordinatus*. The primitive Reniferinae migrated from the gut into the lungs and from there some genera migrated into the mouth cavity, except *Ochetosoma*, which travels there from the intestine. *Xenopharynx* migrates into the bile duct from the small intestine. I once obtained two specimens of

Xenopharynx piscator Bhalerao from the intestine, and a large number from the bile duct and gall bladder of *Tropidonotus piscator*. The bile duct in this case was blocked up with the specimens.

The genera *Mediorima*, *Dasymetra*, *Platymetra*, *Stomatrema* and *Xenopharynx* are not typical of the Reniferinae, but they show primitive features pointing to a close relationship of the latter sub-family with *Styphlodora* or, rather, the primitive Styphlotreminae. The genital pore in these genera is median and just behind or on the intestinal bifurcation. By shifting forwards the cirrus sac in *Styphlodora* we get the position of the genital pore and cirrus sac as found in the above-mentioned genera. In this way the genital pore in these genera has wandered away from the neighbourhood of the ventral sucker and has come to lie much in front, while the cirrus sac does not extend behind the middle of the acetabulum. By further lengthening and shifting laterally the terminal part of the cirrus sac we should get the lengthened and somewhat curved cirrus sac of the typical Reniferinae. The vitellaria in *Mediorima* are feebly developed, as in *Styphlodora*, whereas in *Dasymetra* and *Xenopharynx* they are well developed. In *Mediorima* the intestinal caeca are short; in *Stomatrema*, *Dasymetra* and *Xenopharynx* they are long, reaching nearly to the posterior end. The testes in these genera are situated obliquely, one in front of the other as in *Styphlodora*. The occurrence of *Mediorima* in the intestine of *Tropidonotus* is another illustration of the biological fact that the gut-living distomes are primitive as compared with their lung- and bile-inhabiting relations.

The sub-family Cymatocarpinae Baer must be dropped. *Pneumatophilus variabilis* (Leidy) does not show close relationship with *Cymatocarpus* and *Glossidium*; on the other hand it seems to have close relations with the Reniferinae. The position of the cirrus sac, testes and genital pore, absence of the receptaculum seminis and habitat in the lungs of snakes, are sufficient to indicate the systematic position of *Pneumatophilus* in the Reniferinae. The only characters on account of which Baer has placed it in the Cymatocarpinae are the constant occurrence of amphitypy and absence of lateral branches in the excretory bladder. According to Pratt the excretory bladder sends out short lateral projections, which are specially noticeable towards the anterior end. Odhner, however, denies their existence. The occasional appearance of amphitypy is well known in many genera of the family, and that it has become fixed and constant in some genera without there existing any close relationship between them seems to be quite certain. Amphitypy is known to occur occasionally in a few species of *Lepoderma*. In *Tremiorchis ranarum* out of twenty-eight specimens examined by me seventeen showed amphitypic and eleven typic position of gonads. In *Tremiorchis varanum* Verma I found three out of four specimens showing amphitypy. The genera *Cymatocarpus* and *Glossidium* as discussed before belong to the Brachycoeliinae and Styphlotreminae respectively.

I accept the sub-family Enodiotreminae Baer for the genus *Enodiotrema*

Lss. The general topography of the organs indicates the origin of this sub-family as an aberrant branch from *Styphlodora*.

Sub-family *Enodiotreminae* Baer.

A peculiar protrusible copulatory sac with a spacious cavity ("Stachelsac") present, characteristic arrangement of ramified lateral branches of the excretory bladder, cirrus sac small, thick and muscular and placed transversely with its curved blind end round the right side of ventral sucker, vesicula seminalis a long thin convoluted tube lying in the basal part of cirrus sac, testes obliquely placed near each other and receptaculum seminis present.

The sub-family Opisthogoniminae Travassos is accepted for the genus *Opisthogonimus* Lühe. This sub-family closely resembles *Styphlodora* in oblique position of the testes, position and shape of the vesicula seminalis, pars prostatica and cirrus, shape of the cirrus sac, which has become more curved on account of a backward displacement, so that the genital pore lies behind the ventral sucker, position of the ovary contiguous to and outside the proximal end of the cirrus sac, presence of the receptaculum seminis and lateral branches of the excretory bladder and similarity of the host and habitat.

Sub-family *Opisthogoniminae* Travassos.

Genital atrium absent, male and female pores situated near each other, median or somewhat to the left behind ventral sucker, cirrus sac curved more or less in the form of an interrogation mark or letter C, covering left posterior quadrant or half of ventral sucker, vesicula seminalis convoluted and occupying basal part of cirrus sac, pars prostatica long and tubular (short pars prostatica and long ductus in *Op. interrogatus* Nicoll), cirrus present, uterus thick-walled with wide ascending convolutions, oesophagus very short, excretory bladder almost cylindrical with two very short diverticula and lateral branches, the eggs measuring 0·02–0·03 by 0·013–0·015 mm. Found in the buccal and narial cavities and the oesophagus of snakes.

The little-known genus, *Aptorchis* Nicoll, may be provisionally placed in the Styphlotreminae. This genus resembles *Styphlotrema* in the position of its genital pore in front of the ventral sucker over the left intestinal caecum, cirrus sac extending a little behind posterior border of the ventral sucker, symmetrical position of the testes, arrangement of uterine coils and similarity of the host. Absence of the receptaculum seminis and position of the ovary midway between the ventral sucker and testes and that of the vitellaria, however, sharply separate it from the other genera of the sub-family. *Dolichopera* Nicoll may be included as a very aberrant genus in the Reniferinae on account of its genital pore near the right margin of the body on a level with the posterior half of the oral sucker, more or less symmetrical position of the testes and resemblance in the habitat, *i.e.* the intestines and lungs of snakes (Australia). But the position of the ventral sucker behind the middle and that of the testes in the last quarter of the body give it a unique distinction among the Lepodermatidae.

The genus *Encyclometra* Baylis and Cannon is so remarkably different from the other Lepodermatidae that I assign it to a new sub-family Encyclometriinae. Half a dozen specimens of *En. caudata* (Polonio, 1859) were obtained

by me from the oesophagus of *Tropidonotus piscator* and one from the stomach of *Zamanis mucosus* at Allahabad. My specimens were larger, measuring 8–11 mm. in length and 2–2·5 mm. in breadth in the widest part, *i.e.* at the level of the acetabulum. The excretory bladder is Y-shaped with a long main stem and two short but quite prominent cornua as described by Baer. In the specimen obtained from *Zamanis mucosus* the main stem gave off small lateral outgrowths. From the anterior margin of each limb of the bladder near its outer end arises a long bladder-like common collecting excretory tube, which winds its way forwards as far as the anterior level of the pharynx, where it bends to form a loop, and is then continued backwards more or less in a straight course to the region just behind the ventral sucker. Two tubules arise from the loop, one going forwards to the anterior end and the other backwards inside the common collecting duct. Baer's account of the excretory tubes is ambiguous; according to him the bifurcation is followed by two tubules, which wind their way forwards as far as the anterior level of the pharynx, where they divide up into smaller tubules. He also mentions in the same way tubules going to the posterior end and to the region in front of the ventral sucker. The common collecting duct is much wider beyond about one-third of its length from the point of origin and takes a wavy course as in the Echinostome larvae. It is so different from that in the Lepodermatidae that I feel constrained to assign this genus to a new sub-family.

Sub-family *Encyclometriinae* Mehra.

Cuticle without spines, common collecting excretory duct, bladder-like and winding forwards as far as pharynx, where it forms a loop to continue backwards, ova precociously developed, miracidia being contained in them *in utero*, cirrus sac slightly curved posteriorly and occupying a transverse position entirely in front of ventral sucker, genital pore situated considerably to the left side, convoluted vesicula seminalis occupying basal part of cirrus sac, pars prostatica well developed, ductus ejaculatorius long and curled on itself before opening to the exterior, vitellaria composed of more or less isolated follicles, commencing behind ventral sucker and terminating near posterior end of body, receptaculum seminis tubular passing distally into a convoluted Laurer's canal, descending and ascending uterine convolutions arranged in right and left halves of body, and ova large, measuring 0·0748–0·095 by 0·03–0·057 mm. Found in the oesophagus, stomach and intestine of *Tropidonotus* and *Zamanis*.

It appears that *Encyclometra* occupies an intermediate position between the Lepodermatidae and Ommatobrephidae Poche.

The sub-family Prosthogoniminae Lühe should be included in the Lepodermatidae, to which Odhner assigned it in 1911 on account of the Y-shaped excretory bladder and resemblance in the general anatomy. Nicoll in 1914 removed it from this family, and assigned it with *Stomylotrema* Lss. to the family Cephalogonimidae. Baer excluded the genus *Prosthogonimus*[1] from the Lepodermatidae. Poche in 1925 and Travassos in 1928 follow Odhner in

[1] I have examined *Pr. ovatus* obtained from the bursa Fabricii of the common snipe (*Totanus fuscus*) and wild duck Gadwall (*Chaulelasmus streperus*).

assigning it again to the latter family. There is no doubt that its position in the Cephalogonimidae is unnatural.

It is not possible to assign a proper systematic position to the genera *Oistosomum* Odhner and *Leptophyllum* Cohn until more is known of their anatomy. The genera *Dolichosaccus* Johnston and *Brachysaccus* Johnston, as shown by Perkins, should be included with *Telorchis* Lühe, *Cercorchis* Lühe, *Cercolecithos* Perkins and *Protenes* Barker and Covey in the sub-family Telorchiinae Lss., which, following Fuhrmann, I include in the family Lepodermatidae. The Telorchiinae appears to be closely related to the Styphlotreminae, on account of the general topography of its organs except the testes, position of the genital pore, shape and position of the cirrus sac, long and curled vesicula seminalis, and similarity in the host and habitat. The genus *Eurymetra* Odhner cited by Baer (1924) and Fuhrmann (1928) has no existence; it appeared by mistake in Odhner's paper as pointed out by the author in the list of errata on p. 166. *Heterorchis* Baylis does not belong to the Lepodermatidae. It obviously belongs to the sub-family Pleisiocreadiinae Winfield of the family Allocreadiidae Stossich.

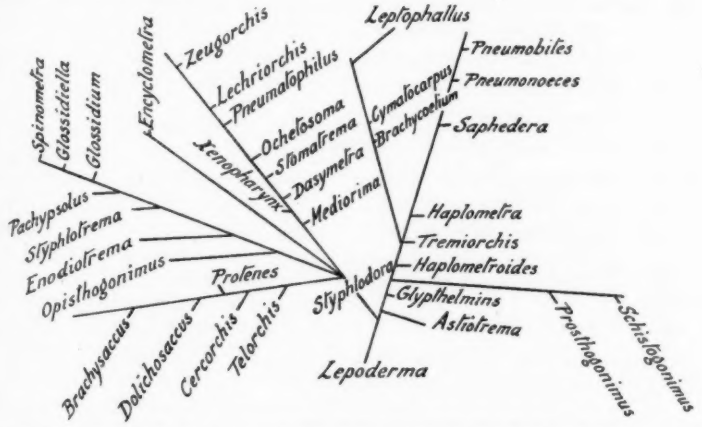

Fig. 6. Tree indicating the probable phylogeny of the family Lepodermatidae.

Family **Lepodermatidae** Odhner.

1. Sub-family Lepodermatinae Looss.
    1. Genus *Lepoderma* Looss (syn. *Plagiorchis* Lühe).
    2. Genus *Haplometra* Looss.
    3. Genus *Haplometroides* Odhner.
    4. Genus *Tremiorchis* Mehra and Negi (syn. *Centrovitus* Bhalerao).
    5. Genus *Astiotrema* Looss.
    6. Genus *Glypthelmins* Stafford.
    7. Genus *Rudolphiella* Travassos.
    8. Genus *Opisthioglyphe* Looss.

2. Sub-family Saphederinae Baer.
    9. Genus *Saphedera* Looss (syn. *Macrodera* Looss).
    10. Genus *Pneumonoeces* Looss (syn. *Haematoloechus* Looss).
    11. Genus *Pneumobites* Ward.
3. Sub-family Brachycoeliinae Looss as amended by Odhner.
    12. Genus *Brachycoelium* Looss.
    13. Genus *Cymatocarpus* Looss.
    14. Genus *Leptophallus* Lühe.
4. Sub-family Styphlotreminae Baer as amended by Mehra.
    15. Genus *Styphlodora* Looss.
    16. Genus *Styphlotrema* Odhner.
    17. Genus *Pachypsolus* Looss.
    18. Genus *Glossidium* Looss.
    19. Genus *Glossidiella* Travassos.
    20. Genus *Spinometra* Mehra.
    21. Genus *Aptorchis* Nicoll.
5. Sub-family Reniferinae Pratt as amended by Mehra.
    22. Genus *Renifer* Pratt.
    23. Genus *Lechriorchis* Stafford.
    24. Genus *Zeugorchis* Stafford.
    25. Genus *Ochetosoma* Braun.
    26. Genus *Pneumatophilus* Odhner.
    27. Genus *Mediorima* Nicoll.
    28. Genus *Dasymetra* Nicoll.
    29. Genus *Platymetra* Mehra.
    30. Genus *Stomatrema* Guberlet.
    31. Genus *Xenopharynx* Nicoll.
    32. Genus *Dolichopera* Nicoll.
6. Sub-family Enodiotreminae Baer.
    33. Genus *Enodiotrema* Looss.
7. Sub-family Opisthogoniminae Travassos.
    34. Genus *Opisthogonimus* Lühe (syn. *Opisthogenes* Nicoll).
8. Sub-family Encyclometriinae Mehra.
    35. Genus *Encyclometra* Baylis and Cannon (syn. *Odhneria* Baer syn. *Paraplagiorchis* Dollfuss).
9. Sub-family Prosthogoniminae Lühe.
    36. Genus *Prosthogonimus* (syn. *Prymnoprion* Looss).
    37. Genus *Schistogonimus* Lühe.
10. Sub-family Telorchiinae Looss.
    38. Genus *Telorchis* Lühe.
    39. Genus *Cercorchis* Lühe.
    40. Genus *Cercolecithos* Perkins.

10. Sub-family Telorchiinae Looss (*continued*).

41. Genus *Protenes* Barker and Covey.
42. Genus *Dolichosaccus* Johnston.
43. Genus *Brachysaccus* Johnston.

Genera Incerta.

44. Genus *Oistosomum* Odhner.
45. Genus *Leptophyllum* Cohn.
46. Genus *Orthorchis* Mödlinger[1].

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[1] The paper containing the account of *Orthorchis* Mödlinger is not accessible to me, therefore I am not in a position to assign it to any sub-family.

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(*MS. received for publication* 15. ix. 1930.—Ed.)

ON TWO NEW SPECIES OF THE GENUS *ASTIOTREMA* LOOSS BELONGING TO THE FAMILY LEPODERMATIDAE ODHNER.

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(With 4 Text-figures.)

The genus *Astiotrema* Looss is parasitic in reptiles (tortoises and snakes), except *Ast. impletum* Looss, which is known from a fish *Tetradon fahaka*. Hitherto three species of this genus have been recorded, two from Egypt and one from Naples (Italy). The present paper contains an account of two more species obtained from tortoises at Allahabad. The allied genus *Glypthelmins* Stafford is parasitic in Amphibia in North America.

Baer (1924) has included both these genera in a new sub-family Astiotreminae Baer on account of a reduced cirrus sac and absence of a protrusible cirrus. According to both Looss (1899) and Odhner (1911) and my own description, the cirrus sac in *Astiotrema* is not reduced in size, but it differs in shape from that of the genera constituting the sub-family Lepodermatinae Looss. It is narrow and fine in its small terminal part, and broad and saccular in its basal part, extending far behind the ventral sucker unlike the cirrus sac of the Lepodermatinae, which is more or less uniformly broad, extending slightly behind the ventral sucker. A protrusible cirrus, though small, is present in *Astiotrema* and *Glypthelmins*. In view of these facts and the close resemblance which these genera show in all other features of their anatomy, it seems necessary to drop the sub-family Astiotreminae. It is not desirable to multiply sub-families on the basis of relatively minute differences without taking into account the totality of organisation. It would be subversive of the whole object of natural classification if the sub-families are not founded on relatively deep-seated characters, so that the affinities and systematic position of the genera contained within them are not lost sight of.

Historical account and diagnosis of *Astiotrema*.

This genus was founded by Looss in 1899, who included in it two species, *Ast. reniferum* Looss and *Ast. impletum* Looss. Odhner in 1911 described these species more fully, pointing out the incompleteness of the description of *Ast. reniferum* given by Looss, and gave a general account of the genus. Stossich in 1904 had described a third species *Ast. monticelli*, the specimens of which

had been obtained by Monticelli in April 1891 from the intestine of *Tropidonotus viperinus*, and referred wrongly by him as *Dist. signatum* Duj. This species was later considered as new and consequently named *Dist. ercolanii*, and is now known as *Ast. monticelli* Stoss. Besides *Ast. reniferum* and *Ast. implexum* Looss had included a third species *Dist. erinaceum* Poirier, which Stossich also included in his table giving the characteristic features of the species of this genus. Odhner, however, excluded it, saying that it belonged to the Monostomidae as *Galactosomum lacteum* (Jägerskiöld, 1896) or a closely related form, with which we entirely agree. In view of the previous work as outlined above and our own observations, the diagnosis of this genus as given by Looss needs a certain amount of modification and amplification.

Diagnosis. Body tongue-shaped or somewhat elliptical, cuticle smooth or covered with spines, anterior and posterior ends somewhat rounded, the latter always broader, ventral sucker in first quarter or between first and second quarters. Prepharynx and pharynx present, intestinal bifurcation a little or much in front of ventral sucker or near its posterior margin, intestinal caeca terminating at anterior or posterior margin of posterior testis or half-way between posterior testis and posterior end of body. Genital opening median or slightly to the left, close in front of ventral sucker. Testes rounded or ovoid, entire or lobed, situated obliquely or somewhat in tandem. Ovary rounded, sub-spherical or elongated, entire or lobed, situated in front of testes behind ventral sucker, usually to the right, rarely to the left. Cirrus sac muscular, more or less conical, with a broad basal saccular part extending far behind ventral sucker, and a narrow tubular terminal part situated dorsally or close to right side of the latter; vesicula seminalis large, straight and thin-walled, filling entirely the saccular part of cirrus sac; pars prostatica short; small protrusible cirrus usually present. Receptaculum seminis present; Laurer's canal long. Uterus convoluted with ascending and descending convolutions characteristically arranged, and passing between testes to hinder end of body and returning forwards the same way. Vitellaria composed of pear-shaped follicles more or less arranged in groups, extending from middle of oesophagus, intestinal bifurcation or ventral sucker to middle of anterior testis, anterior or posterior margin of posterior testis or a little in front of posterior end of body. Excretory bladder **Y**-shaped with a long cylindrical or slightly **S**-shaped main stem extending forwards as far as receptaculum seminis, where it divides into two prominent cornua, excretory pore terminal or ventral a little in front of hinder end. Ripe ova measuring 0·0238–0·041 mm. by 0·0102–0·015 mm. in size. Habitat: stomach and intestine of tortoises and snakes (*Tropidonotus*) and fish (*Tetradon*). Locality: Egypt, Italy and India.

Astiotrema elongatum *sp.n.*

Eight specimens of this species were obtained in 1926, one from the duodenum and seven from the small intestine of *Trionyx gangeticus* at Allahabad. The parasites do not appear to be common; out of one dozen tortoises

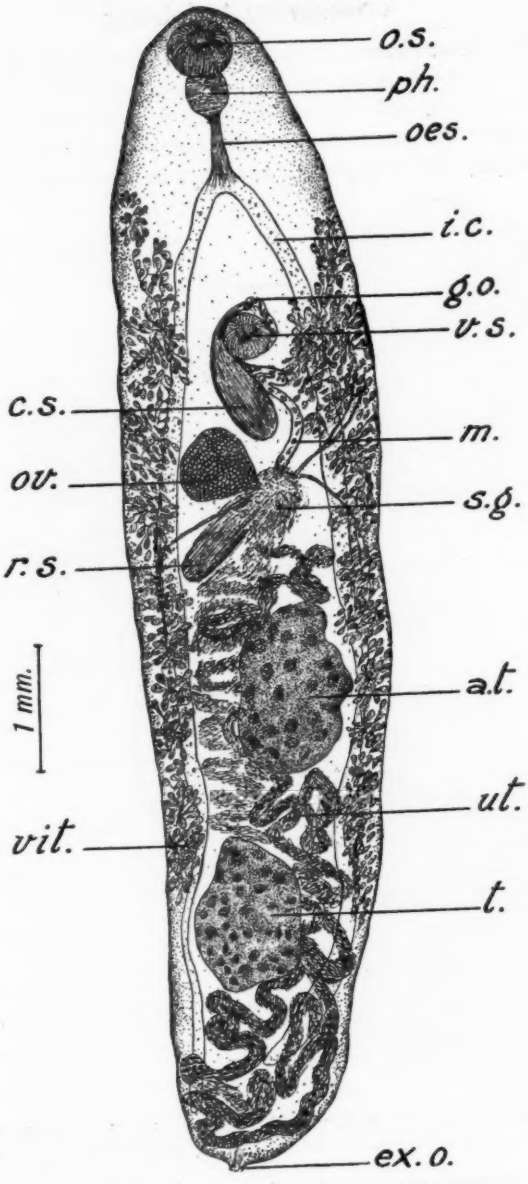

Fig. 1. *Astiotrema elongatum* sp.n., ventral aspect.

Lettering to Figs. 1–4: *a.t.* anterior testis; *c.* cirrus; *c.s.* cirrus sac; *ex.o.* excretory opening; *g.o.* genital opening; *i.c.* intestinal caecum; *L.c.* Laurer's canal; *m.* metraterm; *oes.* oesophagus; *o.s.* oral sucker; *oo.* ootype; *ov.* ovary; *ovi.* oviduct; *p.g.* prostate gland cells; *ph.* pharynx; *p.p.* pars prostatica; *r.s.* receptaculum seminis; *s.g.* shell gland; *t.* posterior testis; *t.v.d.* transverse vitelline duct; *ut.* uterus; *vit.* vitellaria; *v.s.* ventral sucker; *v.sm.* vesicula seminalis; *v.r.* vitelline reservoir.

examined only one was found to be infected. The distomes are elongated, somewhat elliptical in shape, measuring 9–12 mm. under pressure of a coverglass. The breadth varies in different regions, but it is greatest in the region of the ovary, measuring 2·1–3 mm. The anterior and posterior ends are somewhat rounded, specially the latter, which is always broader. The body in front of

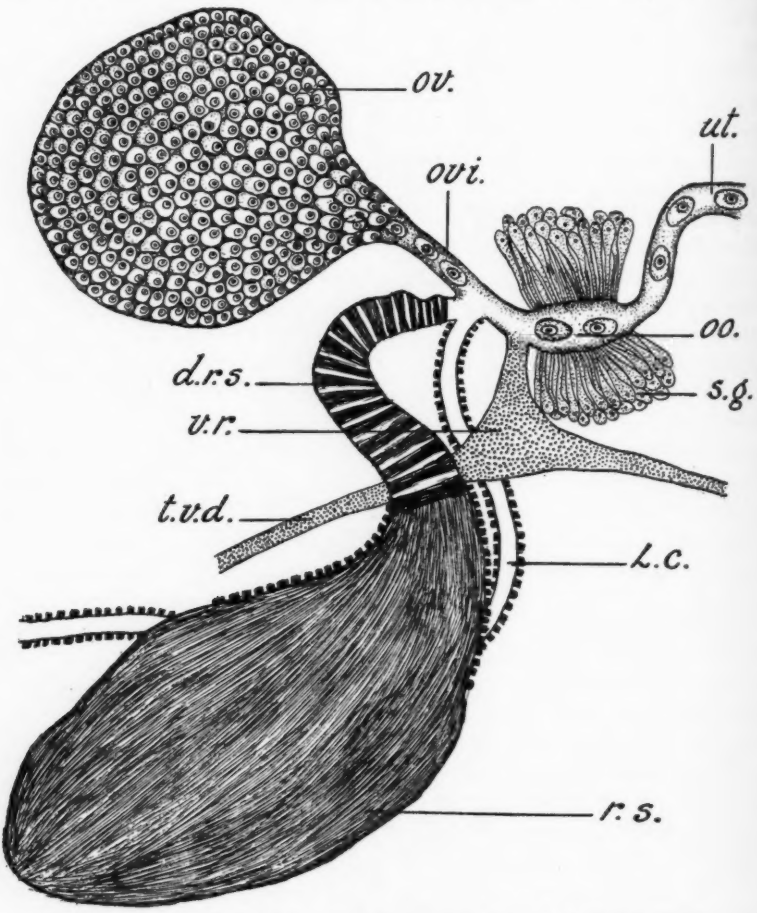

Fig. 2. *Astiotrema elongatum* sp.n., semi-diagrammatic view of the female organs constructed from a series of longitudinal sections. (For lettering *see* Fig. 1.)

the anterior testis is covered with minute pointed scales of 0·0204 mm. length and 0·0078 mm. breadth in the region of the intestinal fork. Around the oral sucker the scales are numerous and much more closely situated, but smaller in length and not sharply pointed. Though this species is much larger than *Ast. reniferum*, its spines are nearly half the size and about equal to

those of the other equally small-sized species, *i.e. Ast. impletum*. The suckers are nearly spherical. The oral sucker is larger than the ventral, measuring 0·49–0·62 mm. in diameter. The ventral sucker measures 0·36–0·53 mm. in diameter, and is situated at 2·42–3·06 mm. distance from the anterior end, *i.e.* at the end of about the first quarter of the body length. The genital opening

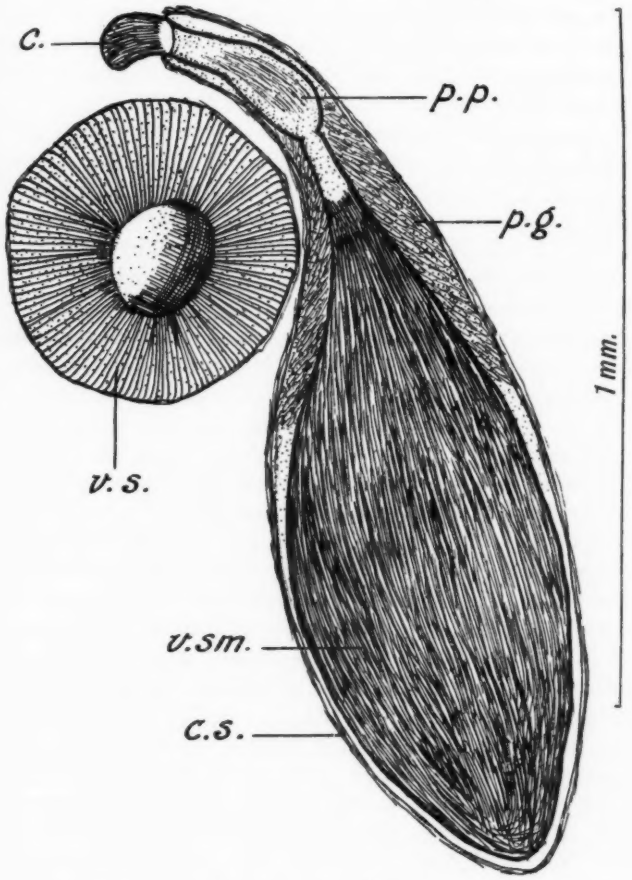

Fig. 3. *Astiotrema elongatum* sp.n., cirrus sac with its contained organs highly magnified. (For lettering *see* Fig. 1.)

lies immediately in front of the ventral sucker slightly to the left. The prepharynx is present. The pharynx is more or less spherical, measuring 0·26–0·33 mm. by 0·32–0·37 mm. in size, and is notched in front and behind. The anterior cornua, which are directed outwards and forwards, mark off, with the depression enclosed between them, the posterior boundary of the prepharynx.

The oesophagus is moderately long, having a length of 1½–3 times the diameter of the pharynx, according to the degree of contraction. The intestinal bifurcation lies about midway between the two suckers. The intestinal caeca run more or less straight, and terminate about half-way between the posterior margin of the posterior testis and the hinder end of the body, converging slightly towards each other near the end.

The testes are large and massive, situated one behind the other, separated by a distance of 0·6–1·3 mm. in the posterior half of the body, and occupying much space between the caeca. The anterior testis of an ovoid shape lies mesially, extending more to the left, and is larger, measuring 1·31–1·35 mm. in length and 0·9–1·2 mm. in maximum breadth. It has somewhat irregular margins, but it is not deeply indented so as to be divided into lobes. The posterior testis has entire margins, and occupies a median position extending more towards the right, having a broad triangular shape with the apex directed forwards and measuring 1·3–1·35 mm. in length and 0·8–1·2 mm. in breadth. The vasa efferentia arise from their anterior pointed ends, and unite before entering the cirrus sac to form a small, rather inconspicuous vas deferens.

The cirrus sac is large, extending far behind the ventral sucker as far as the ovary and measuring 1·08–1·46 mm. in length and 0·37–0·46 mm. in maximum breadth. It occupies a more or less median position with its long axis parallel to the length of the body and its narrow terminal part bent closely round the right side of the ventral sucker or covering dorsally its right margin. The basal saccular part of the cirrus sac, pear-shaped in form, is covered by a thick wall of longitudinal muscle fibres. The muscular wall of the tubular part is much thinner. The vesicula seminalis is large and pear-shaped, filling entirely the saccular part of the cirrus sac, except terminally, where it is surrounded by the prostate cells. It measures 0·8–1 mm. in length and about half as much in breadth, having a thin wall of longitudinal muscle fibres, and is separated from the pars prostatica by a constriction in which a pair of forwardly directed membranous flaps project from the side walls, controlling the discharge of sperms. The pars prostatica is somewhat oval or pear-shaped, measuring 0·1–0·12 mm. in length and 0·08–0·09 mm. in breadth, occupying almost the entire breadth of the tubular part of the cirrus sac. The ductus ejaculatorius, 0·33 mm. in length, passes into a small, stout, eversible cirrus which, as seen protruded in one specimen, measures 0·1 mm. in length and 0·06 mm. in breadth. The male opening lies to the right side of the female opening in the shallow genital atrium.

The ovary is spherical or sub-spherical, measuring 0·58–0·65 mm. in diameter, and lies to the right side, touching the right intestinal caecum, 0·6–0·8 mm. distance behind the ventral sucker and almost immediately behind the cirrus sac. On its inner side about the middle of its length it is produced into a bluntly pointed process, from which the oviduct arises. The oviduct is joined separately by the duct of the receptaculum seminis and Laurer's canal, and soon after receives more mesially a small duct from the vitelline reservoir.

The ootype is slightly dilated and surrounded by large shell gland cells. The shell gland complex is large, occupying a median position inwards to the ovary and receptaculum seminis. The receptaculum seminis, of a pear-shaped or ovoid outline, is larger than the ovary, measuring 0·8–0·89 mm. in diameter, situated somewhat obliquely to the right side, immediately behind the ovary, with its long axis parallel to the length of the body. Its inner end is produced into a wide duct, which takes an **S**-shaped twist before it opens into the oviduct. The Laurer's canal is long and somewhat convoluted. After its junction with the oviduct it takes a backward course to the right side to pass dorsally, where it opens by a minute pore in the mid-dorsal line. On the side opposite to that from which it receives the oviduct, the ootype passes into the first coil of the descending uterus situated to the right side behind the seminal receptacle. The uterus winds its way backwards between the two testes into the posterior part of the body to return forwards by the same way, the convolutions making a characteristic **S**-shaped twist between the ovary and posterior testis. The coils are transversely arranged, rarely overlapping the gut diverticula except in the part behind the testes, where they are both longitudinally and transversely arranged, covering the intestinal caeca. The metraterm is a slightly convoluted muscular tube, which runs forwards to the left side of the ovary, cirrus sac and ventral sucker, partly overlapping the last two structures on the dorsal side. Its terminal broad part, which opens into the genital atrium by a small narrow duct, is invariably filled with ova. The ripe ova have a yellowish brown shell, measuring 0·0304–0·0368 mm. in length and 0·0102–0·012 mm. in maximum breadth.

The vitellaria are laterally situated mainly outside the caeca, and partly overlapping them dorsally and ventrally. They commence just behind the intestinal bifurcation, usually about half-way between the latter and the ventral sucker, and terminate at about one-fourth to one-third the length of the posterior testis, always leaving a small terminal part of the caeca uncovered. Each vitelline gland consists of ten to twelve groups of more or less widely separated pear-shaped follicles, anterior and posterior groups sometimes running together to form continuous bands. The anterior and posterior longitudinal ducts join about the posterior margin of the ovary or the anterior margin of the receptaculum seminis to form the transverse ducts. The vitelline reservoir lies dorsally in the shell gland complex inwards to the duct of the receptaculum seminis.

The excretory opening is terminal. The main stem of the excretory bladder extends forwards beyond the anterior testis, reaching the anterior border of the receptaculum seminis, where it divides into two short but wide cornua which run diagonally one on each side. The main stem lies median, occupying about half the length of the body and is slightly curved in an **S**-shaped manner.

This species is characterised by the large size of the body, great length of the oesophagus, position of the intestinal bifurcation much in front of the ventral sucker about half-way between the two suckers, position of the ovary

immediately behind the cirrus sac, testes longer than broad and the vitellaria terminating a small distance in front of the blind ends of the caeca. The other features which distinguish it are the size of the suckers, shape of the pharynx, presence of a small stout cirrus, size of the testes, ovary and ova.

Ast. elongatum resembles *Ast. reniferum* in the proportion of the length of the intestinal caeca to the length of the body, position of the vitellaria, shape of the testes with somewhat notched margins, large size of the receptaculum seminis and in the hosts belonging to different species of *Trionyx*. In possessing a protrusible cirrus and in the shape and size of the spines and size of the ova it resembles *Ast. impletum*.

Astiotrema loossii *sp.n.*

Only one specimen of this species was obtained from the small intestine of *Kachuga dhongoka* in December 1929. The body measures 2·7 mm. in length and 1 mm. in maximum breadth, which is in the region containing the anterior testis. The shape is more or less elliptical. The posterior end is much broader than the anterior, which is bluntly pointed. The cuticle is devoid of spines. The anterior sucker is terminal, situated at the anterior blunt extremity, facing ventrally and measuring 0·18 mm. in diameter. The ventral sucker is larger, having 0·23 mm. diameter. The ratio in the size of oral and ventral suckers is nearly 3 : 4. The ventral sucker is situated at a distance of 0·62 mm. from the anterior end and 1·8 mm. from the posterior end, thus occupying a position between the first and second quarters of the body. The excretory opening lies on the ventral surface a little in front of the hinder extremity. The genital pore lies median, close in front of the ventral sucker.

A small prepharynx is present. The pharynx is pear-shaped, measuring 0·13 mm. in length and 0·11 mm. in maximum breadth about the middle of its length. The oesophagus is moderately long, having 0·18 mm. length and 0·02 mm. breadth. The intestinal bifurcation lies 0·12 mm. distant in front of the ventral sucker. The intestinal caeca terminate a little in front of the posterior extremity of the body at about half-way between it and the posterior testis. The right intestinal caecum ends a little behind the left one. The caeca are narrow up to the region of the ovary, behind which they gradually broaden, attaining the greatest breadth in the part between the middle of the anterior testis and their blind ends.

The ovary lies to the right side, touching externally the right intestinal caecum, and 0·13 mm. distance behind the ventral sucker with its anterior half to the right side of the cirrus sac. It is kidney-shaped, with its convex outer side produced into lobes, having 0·3 mm. length and 0·12 mm. maximum breadth. The shell gland complex lies inwards to and near the hinder end of the ovary. The receptaculum seminis and Laurer's canal are very small.

The testes lie obliquely in the posterior half of the body. The anterior testis is much lobed, measuring 0·33 mm. in diameter, and is situated to the left side, touching the left intestinal caecum immediately behind the ovary

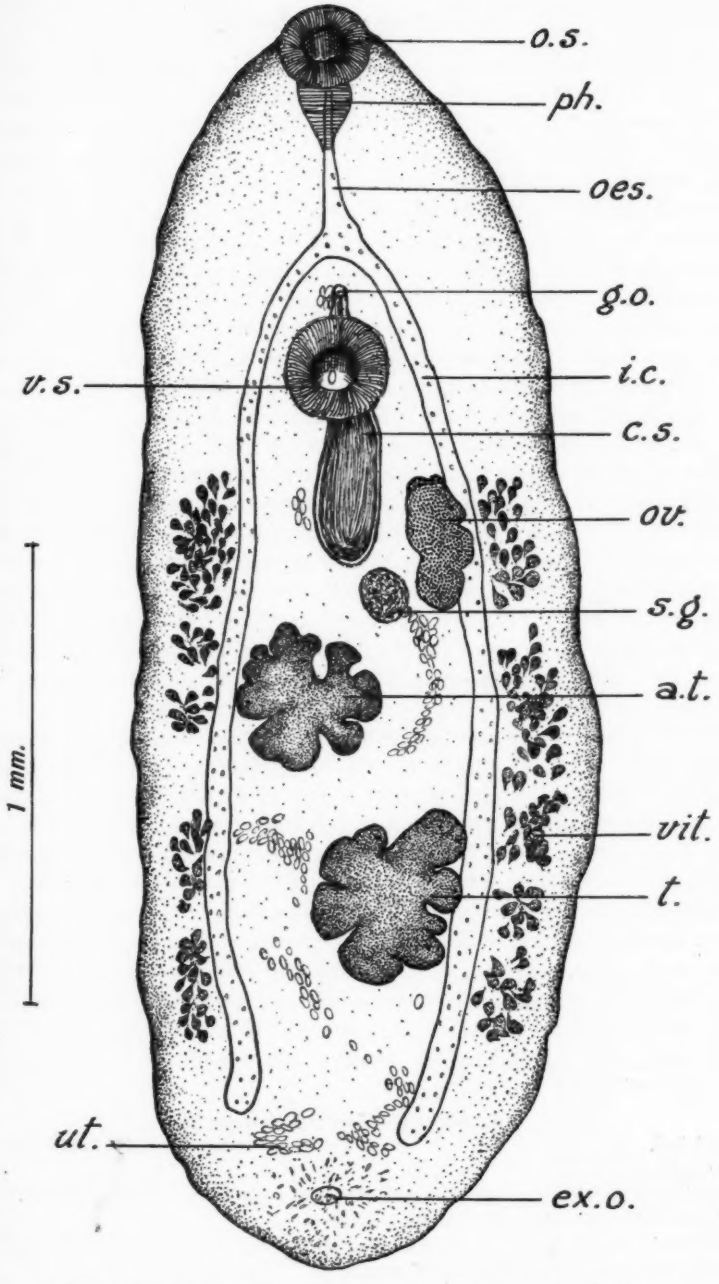

Fig. 4. *Astiotrema loossii* sp.n., dorsal aspect. (For lettering *see* Fig. 1.)

and 0·4 mm. behind the ventral sucker. The posterior testis is situated to the right side, occupying the entire space between the median line and left intestinal caecum, 0·12 mm. distance behind the anterior testis and 0·6 mm. distance in front of the hinder end of the body. It is much lobed and slightly larger than the anterior testis, measuring 0·35 mm. in length and 0·3 mm. in maximum breadth. The cirrus sac consists of a large saccular part, extending far behind the ventral sucker as far back as the middle of the ovary, with its long axis median and parallel to the length of the body, and a narrow tubular terminal part of a more or less uniform breadth lying dorsally to the right half of the ventral sucker except near the genital opening. The cirrus sac has thick muscular walls, and measures 0·6 mm. in length and 0·15 mm. in maximum breadth about the middle of its saccular part. The vesicula seminalis is large and voluminous, having its walls in close contact with those of the cirrus sac. The pars prostatica and ductus ejaculatorius are small as in the other species.

The uterus is not much convoluted, as the specimen is obviously not sexually mature. Both the ascending and descending parts pass backwards between the testes, forming a small convoluted knot behind the posterior testis between it and the ventrally placed excretory opening. The course of the uterus is S-shaped as in the other species of the genus. The metraterm runs about the median plane of the body inwards to the cirrus sac, passing dorsally to the ventral sucker to open into the genital atrium. The ripe ova are yellowish brown and oval in shape, measuring 0·0238 mm. in length and 0·0136 mm. in maximum breadth.

The vitellaria commence behind the ventral sucker about the anterior margin of the ovary, and terminate a little behind the posterior testis and about 0·16–0·26 mm. distance in front of the blind ends of the caeca. Each yolk gland is composed of pear-shaped follicles arranged in a small number, *i.e.* of five to six, grape-like bunches separated from each other. The glands lie outside the intestinal caeca much nearer the latter than the body wall.

This species is characterised by the elliptical form of the body, absence of spines, terminal position of the oral sucker, shape of the ovary, larger size of the ventral sucker, great length of the intestinal caeca, arrangement of vitellarian follicles in a small number of grape-like bunches and the ventral position of the excretory opening. It, however, resembles *Ast. reniferum* in small size of the body, size of the cirrus sac, length of the oesophagus and presence of the lobed testes.

Key to the species of the genus Astiotrema *Lss.*

Ovary lobed.	*Ast. loossii* sp.n.
Ovary entire.	
Intestinal bifurcation at posterior margin of ventral sucker.	*Ast. monticelli.*
Intestinal bifurcation in front of ventral sucker.	
Vitellaria terminating at middle of anterior testis.	*Ast. impletum.*
Vitellaria terminating behind anterior testis.	
Diameter of suckers 0·25–0·3 mm. Testes broader than long.	*Ast. reniferum.*
Diameter of suckers 0·36–0·62 mm. Testes longer than broad.	*Ast. elongatum* sp.n.

Table I. *Showing characteristics of the species of the genus* Astiotrema.

	Species	Host	Size of suckers	Oesophagus	Intestinal caeca	Testes	Ovary	Vitellaria	Ova (mm.
1.	*Ast. reniferum* Lss. (*Dist. unicum* Lss.) 1899 and 1900, Odhner, 1911	Small intestine of *Trionyx nilotica* and *T. triunguis*, Egypt	Oral slightly larger than ventral; 0·25–0·3 mm.	Moderately long; bifurcates a little in front of ventral sucker	Reach four-fifths body length near end of posterior testis	Somewhat obliquely situated; broader than long	Somewhat rounded	From ventral sucker or rarely intestinal bifurcation to anterior or posterior margin of posterior testis	0·026–0·029 by 0·011
2.	*Ast. impletum* Lss. 1899, Odhner, 1911	Mid-gut of *Tetradon fahaka*, Egypt	Oral one and a half times ventral; oral 0·34 mm. and ventral 0·16–0·22 mm.	Moderately long; bifurcates in front of ventral sucker and behind genital pore	Terminate at three-fifths body length near end of posterior testis	Somewhat obliquely situated; sub-spherical, margins occasionally notched	Rounded	From middle of oesophagus to middle of anterior testis	0·037–0·041 by 0·015
3.	*Ast. monticelli* Stossich, 1904	Intestine of *Tropidonotus viperinus*, Naples (Italy)	Oral slightly larger than ventral	Long; bifurcates at posterior margin of ventral sucker	Ending nearly at anterior margin of posterior testis	Slightly in front of each other; globular	Rounded	From middle of cirrus sac to middle of anterior testis	—
4.	*Ast. elongatum* sp.n. 1930	Small intestine of *Trionyx gangeticus*, Allahabad (India)	Oral slightly larger than ventral; 0·36–0·62 mm.	Long; bifurcates much in front of ventral sucker	Terminate at about nine-tenths body length, half way between posterior testis and hinder end of body	More or less in tandem; ovoid with entire or somewhat irregular margins; longer than broad	Rounded	From half way between intestinal fork and ventral sucker to about one-third length of posterior testis	0·0304–0·0368 by 0·0102–0·012
5.	*Ast. loossii* sp.n. 1930	Small intestine of *Kachuga dhongoka*, Allahabad (India)	Ventral slightly larger than oral; 0·18–0·23 mm.	Moderately long; bifurcates slightly in front of ventral sucker	Terminate a little in front of hinder end but not at the same level	Obliquely close behind each other; much lobed	Kidney-shaped and lobed	From anterior margin of ovary to a little behind posterior testis. Follicles arranged in a few grape-like bunches	0·0238 by 0·0136

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(*MS. received for publication* 15. IX. 1930.—Ed.)

ON A NEW TREMATODE *MICRODERMA ELINGUIS* N.G., N.S.

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(With 1 Text-figure.)

Four specimens of this trematode were obtained from the small intestine of *Kachuga smithii* in December 1929. Two of the specimens were not sexually mature; for though they possessed well-developed testes, ovary and a very small receptaculum seminis, they lacked the uterus and ova. In one of these immature specimens the vitellarian follicles were very feebly developed.

The distomes measure, when slightly flattened, 2–3·5 mm. in length and 0·3–0·4 mm. in maximum breadth in the region between the ventral sucker and the end of the posterior testis. The body is elongated, with rounded anterior and posterior ends, the latter being always somewhat broader. The body in front of the ovary is beset with pointed spines, which are very minute, hardly projecting beyond the cuticle. Around the oral sucker and pharynx the spines are somewhat larger and more numerous. The oral sucker lies subterminally at the anterior end, measuring 0·08–0·09 mm. in diameter. The ventral sucker is slightly larger, having 0·11–0·12 mm. diameter, and is situated at a distance of 0·48–0·83 mm. from the anterior end, occupying a position at about the end of the first one-fourth of the body length. The ratio in the size of the oral and ventral suckers is about 3 : 4. The genital opening lies medially, immediately in front of the ventral sucker.

A small prepharynx is present. The pharynx is spherical, measuring 0·04–0·06 mm. in diameter. The oesophagus being entirely absent, the pharynx is immediately followed by the intestinal bifurcation, which lies 0·3–0·6 mm. in front of the ventral sucker. The intestinal caeca extend much behind the posterior testis, reaching a little in front of the hinder end of the body. They are broader some distance in front of the ventral sucker, and lie for a great part of their length about half-way between the median line and the body wall, ending at the same level.

The testes lie obliquely close behind each other in the posterior half of the body, and are spherical with entire margins, having nearly equal size, measuring 0·16–0·23 mm. in diameter. The anterior testis lies to the right side far behind the ovary at 0·5 mm. distance behind the latter and 0·9 mm. behind the ventral sucker in the largest specimen, whereas in a specimen of 2 mm. length

it lies 0·27 mm. behind the ovary and 0·67 mm. behind the ventral sucker. The posterior testis lies to the left, close behind the anterior testis, separated from it by a distance of 0·07–0·2 mm., and 0·6–0·9 mm. distance in front of the posterior end of the body. The vasa efferentia arise from the middle of the anterior margin of the testes; the one arising from the posterior testis runs close inside the left intestinal caecum, and that from the anterior testis close to the right intestinal caecum. In front of the ovary they converge towards each other, running separately up to the base of the cirrus sac, where they unite to form a very small, rather inconspicuous vas deferens. The cirrus sac of moderate size and thick muscular walls lies close to the right side of the ventral sucker, more or less curved round it in a crescent-shaped manner with its basal saccular part extending some distance behind it, but not so far behind as in the genus *Astiotrema* Looss. In the largest specimen it is slightly curved in an S-shaped manner, *i.e.* not only is its tubular part curved round the ventral sucker but the basal saccular part is also somewhat curved outside (Fig. 1). The vesicula seminalis is large and straight in the basal part of the cirrus sac, but it curls on itself before passing into the pars prostatica. It is as usual filled with sperms, and lies separated, for a great part of its length, from the walls of the cirrus sac by the intervening prostate gland cells. The pars prostatica and ductus ejaculatorius are small, the former not being distinctly recognisable. The prostate gland cells of small size and pear-shaped form surround the vesicula seminalis, pars prostatica and a small proximal part of the ductus ejaculatorius. A protrusible cirrus has not been observed. The genital atrium is large, and opens to the exterior by a wide genital pore situated in the median line a little in front of the ventral sucker.

The ovary is rounded, having 0·15–0·2 mm. diameter, and lies a little in front of the posterior half of the body, 0·17 mm. distance behind the cirrus sac and 0·23–0·33 mm. behind the ventral sucker to the right side, with its outer margin close to the right intestinal caecum. The receptaculum seminis is much smaller than the ovary. The Laurer's canal is present. The shell gland complex and receptaculum seminis lie close behind the ovary, slightly to the right side or in the median line. The uterus runs backwards between the testes to the posterior end of the body, filling more or less the space between the intestinal caeca and rarely overlapping the latter in a few places. Behind the caeca it nearly fills the space within the body. The descending and ascending uterine convolutions overlap each other and are transversely arranged. Ventrally to the cirrus sac the uterus ends in the metraterm, which opens into the genital atrium and lies for a great part of its length close to the right side of the distal half of the cirrus sac. The metraterm is surrounded by a thin layer of parenchymatous cells with deeply staining nuclei. The genital atrium is large, the cirrus sac opening into it a little behind the genital opening to the left and the metraterm to the right. The ripe ova are oval in shape and yellowish brown in colour, measuring 0·0238 mm. in length and 0·0136–0·0146 mm. in maximum breadth.

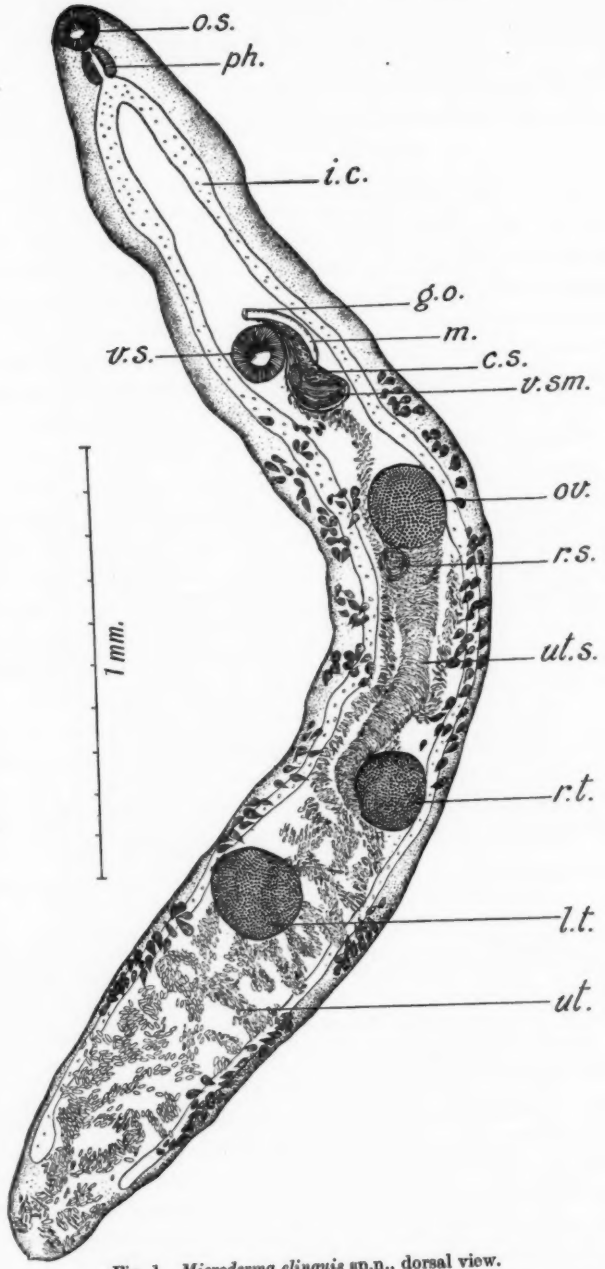

Fig. 1. *Microderma clinguis* sp.n., dorsal view.

c.s. cirrus sac; *g.o.* genital opening; *i.c.* intestinal caecum; *l.t.* left testis; *m.* metraterm; *o.s.* oral sucker; *ov.* ovary; *ph.* pharynx; *r.s.* receptaculum seminis; *r.t.* right testis; *ut.* uterus; *ut.s.* part of descending uterus filled with sperms; *v.s.* ventral sucker; *v.sm.* vesicula seminalis.

The vitellaria are laterally situated near the body wall, outside and overlapping the intestinal caeca, sometimes extending inwards to the latter. They commence behind the ventral sucker near the posterior end of the cirrus sac and terminate close in front of the blind ends of the intestinal caeca, but not at the same level; the left gland which usually commences a little in front of the right one terminates always slightly anterior to the latter. The follicles, pear-shaped in outline, are arranged in groups, which anteriorly and posteriorly may run together to form continuous bands. The transverse vitelline ducts arise at the level of the receptaculum seminis.

The excretory pore lies terminally at the posterior end of the body. The excretory bladder is Y-shaped, with a long main stem, which bifurcates at the level of the shell gland complex into the cornua. The bladder is apparently devoid of lateral branches.

Diagnosis. Cuticle beset with minute spines, ventral sucker slightly larger than oral sucker. Oesophagus entirely absent, intestinal bifurcation far in front of ventral sucker, intestinal caeca reaching a little in front of hinder end. Genital opening median, immediately in front of ventral sucker. Testes spherical, about equal in size, placed obliquely close behind each other. Ovary situated to the right in front of testes, receptaculum seminis much smaller. Laurer's canal present. Vitellaria laterally situated, commencing behind ventral sucker and terminating close in front of ends of intestinal caeca. Cirrus sac of moderate size with thick muscular walls, extending behind ventral sucker with terminal part curved closely round right side of the latter. Vesicula seminalis curling on itself near small and indistinctly recognisable pars prostatica. Metraterm present; genital atrium well developed. Excretory bladder Y-shaped without lateral branches. Host: *Kachuga smithii*. Locality: Allahabad, India.

Systematic position of the genus *Microderma*.

I include this genus in the sub-family Lepodermatinae Looss as recently defined by me (1930). *Microderma* is remarkable in showing relationships to the genera *Lepoderma* and *Astiotrema* on the one hand, and *Styphlodora* on the other; it occupies, therefore, the unique position of a connecting link between the two sub-families Lepodermatinae and Styphlotreminae. It shows marked resemblance to *Lepoderma* in the absence of the oesophagus (absent in many species of *Lepoderma*), position of the cirrus sac to the right side of the ventral sucker, oblique position of the testes, rounded shape of its gonads, median position of the genital pore, intestinal caeca ending a little in front of the hinder end and small size of the ova. But it is sharply separated from *Lepoderma* on account of the presence of a receptaculum seminis, basal part of its cirrus sac extending some distance behind the ventral sucker, curled appearance of the vesicula seminalis, ventral sucker being larger than the oral sucker, vitellaria being less extensive, commencing behind ventral sucker and situated

laterally near the body wall, and difference in the host, *Lepoderma* never being found in a tortoise. In the shape of its cirrus sac *Microderma* somewhat resembles *Astiotrema*.

The main points of resemblance which *Microderma* shows with the genus *Styphlodora* are small size and shape of the body, presence of a short oesophagus in *Styphlodora* and its absence in *Microderma*, oral sucker somewhat smaller than the ventral sucker, intestinal caeca ending a little in front of the hinder end, oblique position of the testes, curled appearance of the vesicula seminalis, pars prostatica not distinctly recognisable, presence of the receptaculum seminis and the uterus passing behind between the testes. The presence of lateral branches in the excretory bladder, feeble development of the vitellaria, shape and position of the cirrus sac in *Styphlodora* and its habitat in the gut of *Varanus niloticus* and ureters of snakes separate the latter genus from *Microderma*.

It may be pointed out that *Plagiorchis lühei* Travassos does not belong to the genus *Lepoderma* syn. *Plagiorchis*. Presence of the receptaculum seminis and coiled vesicula seminalis are of sufficient importance to exclude it from that genus. This species apparently belongs to the genus *Microderma* on account of absence of the oesophagus, curled vesicula seminalis, presence of the receptaculum seminis and position of the vitellaria.

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(*MS. received for publication* 15. IX. 1930.—Ed.)

NEMATODE PARASITES OF VERTEBRATES IN THE PHILADELPHIA ZOOLOGICAL GARDEN AND VICINITY.

II.

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(With Plates VIII and IX including 25 Figures.)

The present paper is the second instalment of the report on the roundworm parasite collection of the Philadelphia Zoological Garden, of which Part I appeared in *Parasitology* (1929, **21**, pp. 63–102). This collection was loaned to the writer by Dr Herbert Fox, in charge of the laboratory and museum there, and consisted chiefly of unnamed material which had accumulated over a period of years.

Part II of the report is presented in the same form as that of the preceding part, and concludes the determinations, together with descriptions of one new genus and five new species.

The fiscal year ending March 1st, 1929, yielded a percentage incidence of infestation of 20 per cent. This is higher than the highest percentage recorded in the history of the Garden, namely 17·6 per cent. in 1928. In 1930 there was a 17·8 per cent. incidence of parasitism—a slight drop only.

Many interesting cases of superparasitism are recorded in Table I. In an opossum (No. 7585), representatives of three separate parasitic classes were found: three Nematodes of the genera *Cruzia*, *Physaloptera*, and *Gnathostoma*; an Acanthocephalan; and a Cestode. In an American wild cat (No. 2842), in addition to the hookworm, ascarid and filarid noted, were also encysted flukes in the mesentery and numerous tapeworms in the small intestine.

Four species of roundworms were found in the ocelot (No. 3598). In several other hosts as many as three different species of roundworms were present at the same time, as for instance, in the American wild cat, Canadian porcupine and camel noted below. Porcupines as a rule harbour several species of filarids in addition to oxyurids usually present. In porcupines (Nos. 3183, 3189, 3190 and 3193; see Table I) it will be noted that species of *Dipetalonema* and of *Dirofilaria* occur in several combinations together and also with an oxyurid.

Table I. *Occurrence of superparasitism.*

No.	Host	Parasite
3598	*Felis pardalis* (ocelot)	*Ancylostoma pluridentatum* (Alessandrini 1905)
		Gnathostoma spinigerum Owen 1836
		Toxocara mystax (Zeder 1800)
		Dirofilaria sp. inq.
2842	*F. rufus* (American wild cat)	*Ancylostoma caninum* (Ercolani 1859)
		Toxascaris leonina (Linstow 1902)
		Dirofilaria sp. inq.
7585	*Didelphys virginiana* (common opossum)	*Physaloptera turgida* (Rudolphi 1819)
		Cruzia tentaculata (Rudolphi 1819)
		Gnathostoma spinigerum Owen 1836
8922	*Camelus dromedarius*	*Haemonchus contortus* Rudolphi 1803
		Ostertagia mentulata Railliet & Henry, 1909
		Oesophagostomum vigintimembrum sp. nov.
3183, 3189	*Erethizon dorsatum*	*Dipetalonema diacantha* (Molin 1858)
3190	(Canadian porcupine)	*Dirofilaria subcutanea* (Linstow 1899)
		Wellcomia evoluta (Linstow 1899)
3193	*E. dorsatum*	*Dipetalonema diacantha* (Molin 1858)
		Dirofilaria subcutanea (Linstow 1899)
3194	*E. dorsatum*	*Dipetalonema diacantha* (Molin 1858)
		Dirofilaria repens (Railliet and Henry 1911)
2828, 5678	*E. dorsatum*	*Dipetalonema diacantha* (Molin 1858)
		Wellcomia evoluta (Linstow 1899)
3515, 3516	*Didelphys virginiana*	*Physaloptera turgida* Rudolphi 1819
7352, 7842 & opossum	(common opossum)	*Cruzia tentaculata* (Rudolphi 1819)
2416	*Rhamphastos carinatus* (sulphur-breasted toucan)	*Habronema incerta* (Smith 1908)
		Acuaria (*Dispharynx*) *crassissima* (Molin 1860)
3033	*Equus zebra* (mountain zebra)	*Strongylus equinus* Mueller 1780
		Parascaris equorum (Goeze 1782)
3167, 3299	*Taxidea taxus* (American badger)	*Physaloptera turgida* Rudolphi 1819
		Physaloptera papillotruncata Molin 1860
3643, 3644	*Felis chans* (jungle kitten)	*Ancylostoma caninum* (Ercolani 1859)
		Toxocara mystax (Zeder 1800)
3683	*Corvus americanus* (common crow)	*Syngamus gracilis* Chapin 1925
		Porrocaecum ensicaudatum (Zeder 1800)
3941	*Felis pardalis* (ocelot)	*Ancylostoma caninum* (Ercolani 1859)
		Trichuris sp. inq.
4764	*Canis dingo* (dingo dog)	*Toxocara canis* (Werner 1782)
		Toxascaris leonina (Linstow 1902)
5348	*Ovis vignei* (Punjab wild sheep)	*Trichuris ovis* (Abildgaard 1795)
		Oesophagostomum venulosum (Rudolphi 1809)
5383	*Poephagus grunniens* (yak)	*Setaria labiato-papillosa* Alessandrini 1838
		Trichuris ovis (Abildgaard 1795)
6493	*Ursus beringiana* (Kamchatkan bear)	*Toxascaris transfuga* (Rudolphi 1819)
		Cyathostoma bronchialis (Muehling 1884)
6772	*Ovis tragelaphus* (aoudad)	*Trichuris ovis* (Abildgaard 1795)
		Oesophagostomum venulosum (Rudolphi 1809)
8523	*O. tragelaphus*	*Trichuris ovis* (Abildgaard 1795)
		Haemonchus contortus Rudolphi 1803
9150	*Camelus dromedarius* (Arabian camel)	*Trichuris ovis* (Abildgaard 1795)
		Haemonchus contortus Rudolphi 1803

Attempts to analyse why these combinations occur, and why other combinations such as hookworms and ascarids are found in one and the same host at the same time, prove futile. The parasites probably do not inhibit each other. Perhaps it is because each takes up a different location within the host. This is the case with the physalopteran *P. turgida* and the oxyurid *Cruzia tentaculata* in opossums, and with the whipworm, *Trichuris ovis*, and the stomach worm, *Haemonchus contortus*, in ruminants. But why one may upon finding one of these species usually be able to find the other and not any of a number of different forms is unexplainable except on the basis of host-specificity in the one case and host-inhibition in the other. The writer notes, however, that host-specificity is not always a reliable criterion, as witness many illustrations of so-called bird parasites in mammals and rodent parasites in ungulates; but it evidently demands some consideration as indicated by certain illustrations given in Table I.

SYNOPTIC LIST INCLUDING NEW SPECIES.

Family TRICHURIDAE Railliet 1915.

Genus TRICHURIS Roederer 1761.

1. **Trichuris ovis** (Abildgaard 1795).

The whipworm of sheep, horse, and dromedary occurred several times with other genera in the following hosts. This species has the narrowed anterior of the body almost thrice as long as the broad posterior. The bacillary band arises about 90μ from the mouth and extends to the union of the two parts of the body. The spicule is long and covered by a spinous sheath in the male. *T. affinis* from *Ovis vignei* is now recognised as synonymous to this species. Males 48–52 mm., females 55–60 mm. in length. Hosts:

P.Z.G.[1] No.

5348 (*a*). *Ovis vignei* (Punjab wild sheep). Large intestine, mild infestation; N.W. India; 6 mo. 4 days.

6772 (*a*). *O. tragelaphus* (aoudad). Colon, few; N.E. Africa; 3 yr. 4 mo.

8523 (*a*). *O. tragelaphus*. Colon, few; N.E. Africa; 4 mo.

5383 (*a*). *Poephagus grunniens* (yak). Intestine, few; born in the Garden; 3 yr. 6 mo.

9150 (*a*). *Camelus dromedarius* (Arabian camel). Lower intestine, heavy infestation; Arabia, Egypt; 14 yr.

2. **Trichuris** sp. inq.

Under this designation the writer places three whipworms (not *T. ovis*).

Those from the elk (*v. infra*) measure 45–48 mm. in length, in both sexes. The male spicule is long and covered with a spinous sheath of numerous small hook-like spines. One female only was found in the ocelot. It is 42 mm. in length. The males and females from the southern eland are of the same length,

[1] P.Z.G. stands for Philadelphia Zoological Garden throughout.

namely 40 mm. each. These males also have a spicule covered with a spinous sheath of numerous small recurved spines. Hosts:

P.Z.G. No.
3417. *Cervus canadensis* (American elk). Large intestine, many; N. America; 4 yr. 7 mo.
3941 (*b*). *Felis pardalis* (ocelot). Small intestine, one female; Texas to S. America; 1 mo. 21 days.
5897. *Taurotragus oryx* (southern eland). Intestine, many; S. Africa; 2 mo. 10 days.

Genus CAPILLARIA Zeder 1800.

3. **Capillaria contorta** (Creplin 1839).

A species with a single spicule in a spined sheath. The spines are recurved as described by Travassos (1915). Lateral bacillary bands are present in the cuticle. Males 8–15 mm., females 15–30 mm. in length. Host:

P.Z.G. No.
3358. *Corvus americanus* (common crow). Under mucosa of stomach, in duodenum, several; N. America; 8 mo.

Family STRONGYLIDAE Baird 1853.

Genus STRONGYLUS Mueller 1780.

4. **Strongylus equinus** Mueller 1780.

This species occurred with *Parascaris equorum* (Goeze 1782) in the zebra. A ventral cervical groove, four teeth in the sub-globular buccal capsule, and leaf-crown elements plate-like undoubtedly place this worm in this species. Its bursal form agrees with the generic description. Males average 16 mm., females 25·5–26 mm. Host:

P.Z.G. No.
3033 (*a*). *Equus zebra* (mountain zebra). Intestine, heavy infestation; S. Africa; 3 mo.

Genus CASTORSTRONGYLUS Chapin 1925.

5. **Castorstrongylus castoris** (Chapin 1925).

The type species and the only one of the genus. Reported from one host only. The many processed leaf-crown elements, the slightly dorsally directed mouth and a spherical buccal capsule are characteristic. The bursa has large lateral and small dorsal lobes. Males 11·5 mm., females 13 mm. Host:

P.Z.G. No.
2936. *Castor canadensis* (American beaver). Caecum, few; N. America; 23 days.

Genus PHARYNGOSTRONGYLUS Yorke and Maplestone 1926.

6. **Pharyngostrongylus brevis** sp. nov. Pl. VIII, figs. 1–5.

This roundworm, taken from the cardiac region of the stomach of a Bernard's kangaroo, proved to be a new species. Despite the many differences between it and *Pharyngostrongylus macropodis* Yorke and Maplestone 1926, I decided to place it in the genus because of the similarities of the male bursa, the pharynx, the female tail and the gradually tapering anterior end. The new species differs from *P. macropodis* in that it has the similarly chitinised ringed

pharynx about one-fourth the length of the latter; the cervical papillae are behind the pharynx, and not in the middle; the anus of the female is three-quarters of the distance between the tip of the tail and the vulva, and not midway; a slightly different male bursal ray; a different corona radiata, etc.

Male. The males are 6–9 mm. in length.

The corona radiata arises from near the anterior end of the buccal capsule and consists of six to ten triangular finely pointed elements. There is one element of the leaf-crown just anterior of each of the six oral papillae. The highest number counted was ten in a dissected specimen. Of the six head papillae, two lateral and four submedian, the two lateral are only slightly larger than the four submedian. The cervical papillae are over the posterior part of the vestibule in *P. macropodis*, but in the new species they are posterior to the cylindrical vestibule with its chitinous ringed walls, and 83μ from the anterior end. The mouth capsule is ring-shaped, 12μ in depth and 24μ broad, or just twice as broad as deep. The chitinous cylindrical vestibuled pharynx with ringed walls follows this; it is 42μ long by 30μ to 32μ broad, and is immediately followed by the oesophagus which is 1·23 mm. long and ends in an enlargement. About 0·814 mm. from the anterior end is a dividing line separating the muscular bands of the oesophagus into anterior and posterior parts. It narrows at this junction and then continues posteriorly the same width to the posterior enlargement. Spicules long, striated, channelled, and about 1·8 mm. in length. Dorsal ray of bursa divided half-way to its base, each limb giving off a short external appendage. The bursa is not cut deep between the limbs as in *P. macropodis*. The limbs are closer together and the external appendages are more pronounced, otherwise the bursa formula fits the generic description (Yorke and Maplestone, 1926, pp. 65–67).

Female. The females are 10–11 mm. in length.

The head characters described for the male apply to the female. The pharynx or chitinous ringed vestibule in the female is 48–52μ in length and 33–37μ in breadth. It is less than a fourth of the length of the same structure in *P. macropodis*; it is on this ground that I have named the new species *P. brevis*. Length of oesophagus 1·29 mm. Excretory pore 0·713 mm. from anterior end. Female tail conical, narrows suddenly at the vulva and the remaining part is dorsally curved. Anus 0·43–0·47 mm. from the tip of the tail, being three-fourths of the distance from the tip of the tail to the vulva. Vulva 0·11–0·17 mm. in front of the anus. Oviparous. Ova large, elongate, 143 × 57μ, and at single cell stage at deposition. The measurements of *P. brevis* and *P. macropodis* are compared in Table II.

Type deposited in the Zoological Laboratory, University of Pennsylvania. Host:

P.Z.G. No.

5964. *Macropus bernardi* (Bernard's kangaroo). Stomach, very numerous; Australia; — (died 1920).

Table II.

	P. brevis sp. nov.	*P. macropodis* Y. & M. 1926
Length of ♂	6–9 mm.	11–12 mm.
Length of ♀	10–11 mm.	14–17 mm.
Mouth capsule	12μ in depth	15μ in depth
	24μ broad	Broader than deep
Corona radiata	6–10 triangular elements	*ca.* 16 triangular elements
	—	*ca.* 200–230μ
Length of pharynx or vestibule		
In ♂	42μ long × 30–32μ broad	Breadth *ca.* 30μ
In ♀	48–52μ long × 33–37μ broad	—
Cervical papillae	83μ from anterior end	*ca.* 140μ from anterior end
Length of oesophagus:		
In ♂	1·23 mm.	*ca.* 2–2·3 mm.
In ♀	1·29 mm.	—
Spicules	*ca.* 1·8 mm.	*ca.* 1·9–2 mm.
Female anus	0·43–0·47 mm. from tip of tail	*ca.* 400μ from tip of tail
Vulva	0·11–0·17 mm. in front of anus	*ca.* 350μ in front of anus

Genus PHASCOLOSTRONGYLUS gen. nov.

Some small Nematodes, taken from the colon of a common wombat, proved to be strongylids of the sub-family Trichoneminae Railliet 1916. They are referred to a new genus related to *Macropostrongylus* Yorke and Maplestone 1926 (p. 75), also a parasite of marsupials. The description of the new genus is as follows:

Mouth directed straight forwards, mouth collar with two lateral sessile head papillae, and four prominent, relatively long, segmented, submedian papillae; buccal capsule cylindrical, thick-walled, with a single leaf-crown of eight rounded elements arising from the internal surface of the capsule and projecting beyond the mouth collar; oesophagus relatively long and club-shaped posteriorly.

Male. With a well-developed bursa having the following formula—ventral rays cleft in the distal portion, externo-lateral, medio-lateral, and postero-lateral rays arise from a common trunk, medio-lateral and postero-lateral fused in the proximal portion and cleft distally, externo-dorsal arises from a common trunk with the dorsal, dorsal ray divided in its distal third, the limbs giving off a short lateral branch; spicules, equal, relatively long, striated, curved at the end and with simple points; gubernaculum present.

Female. Body tapers rapidly from a point in front of the vulva to end in a bluntly conical tail; vulva near anus; uteri parallel, arise from the ovijector just anterior of the vulvular aperture. Oviparous. Parasites of marsupials.

Type species: *Phascolostrongylus turleyi* sp. nov. Males 9–11·3 mm., females 16·5 mm. in length. In *Phascolomys mitchelli*.

7. **Phascolostrongylus turleyi** sp. nov.[1] Pl. VIII, figs. 8–13.

Description of type species of the new genus:

In a few respects the new species resembles *Macropostrongylus australis* Yorke and Maplestone 1926 (p. 75), from a wallaby, Queensland; it also somewhat resembles *M. macropostrongylus* Yorke and Maplestone 1926, and *M. yorkei* Baylis 1927, from the same host. For instance, the female tail, the spicules, the oesophagus, and all the bursal rays excepting the externo-dorsal and dorsal are alike. But it differs from *M. australis* species in having four prominent, relatively long, segmented, submedian head papillae and two sessile lateral papillae, instead of two prominent laterals and four smaller submedian; in having a buccal capsule much larger; in having a leaf-crown of eight rounded elements; and the externo-dorsal ray arising from a common trunk with the dorsal, instead of from a common trunk with the laterals. The dorsal ray is likewise only divided for a distance of one-third of its distal portion. Finally, the bursa does not completely close ventrally as is the case with *M. australis*.

Male. The males measure 9–11·3 mm. in length. The buccal capsule is 44–48μ in depth and 64–66μ in breadth, being thus definitely broader than deep; its walls are strong and curved outward. Arising from the anterior internal edge thereof is the leaf-crown composed of eight rounded elements which cover the mouth cavity and project slightly beyond the mouth collar. The four prominent, relatively long submedian head papillae are 43μ in length, and are composed of three segments each, the connections of which are distinct as the papillae project forward 24μ above the mouth collar. The two lateral papillae are sessile. The excretory pore is situated 425μ from the anterior end about the middle of the oesophagus. Length of the club-shaped oesophagus from the base of the buccal capsule is 572μ. Spicules equal, striated, curved ventrally near the end, and have simple points. They are 1·45 mm. in length. A gubernaculum is present and can be seen just anterior to the bursa.

Female. The females measure 16·5 mm. in length by 0·4–0·43 mm. in breadth. Their oesophagus measures 880μ in length from the base of the buccal capsule. The body tapers rapidly from a point just anterior to the vulva to end in a bluntly conical tail terminating shortly behind the anus. Anus 100μ from the tip of the tail. Vulva 100–110μ in front of the anus. Two parallel uteri join together to form the ovijector 328–358μ anterior to the vulvular aperture. Oviparous. Ova in uteri are unsegmented. Comparative measurements, etc., are given in Table III.

Type deposited in the Zoological Laboratory, University of Pennsylvania. Host:

P.Z.G. No.
2505. *Phascolomys mitchelli* (common wombat). Colon, many; Australia; 10 mo.

[1] Named in honour of Prof. Louis Alvin Turley, former Dean and now acting Professor of Pathology in Oklahoma Medical School, in recognition of his founding the first course in Parasitology in that State.

Table III.

	Phascolostrongylus turleyi gen. et sp. nov.	*Macropostrongylus australis* Yorke and Mapleston 1926
Length of ♂	9–11·3 mm.	7–8 mm.
Length of ♀	16·5 mm.	8·9 mm.
Buccal capsule	44–48μ in depth, definitely broader than deep	12μ in depth, definitely broader than deep
Leaf-crown	Composed of 8 rounded elements projecting slightly beyond the mouth collar	Composed of relatively long elements projecting considerably beyond the mouth collar
Excretory pore	425μ from anterior end	510–560μ from anterior extremity
Length of oesophagus	572μ from base of buccal capsule (in male). 880μ in female	650μ in male; 720μ in female
Spicules	1·45 mm. in length	2·7 mm. in length
External dorsal ray	Arises from a common trunk with the dorsal	Arises from a common trunk with the laterals
Female anus	100μ from tip of tail	160μ from tip of tail
Female vulva	100–110μ in front of anus	120μ in front of anus

Genus OESOPHAGOSTOMUM Molin 1861.

8. **Oesophagostomum venulosum** (Rudolphi 1809).

This oesophagostome has sixteen rounded external leaf-crown elements. It has sixteen internal, with twice as many processes. The cephalic vesicle is well developed and the cervical papillae lie behind the oesophagus. All other characters agree with the specific description. In both cases they occurred with roundworms of other genera. Males 13 mm., females 13–18 mm. in length. Hosts:

P.Z.G. No.

5348 (*b*). *Ovis vignei* (Punjab wild sheep). Intestine, few; N.W. India; 6 mo. 4 days.

6772 (*b*). *O. tragelaphus* (aoudad). Intestine, few; N.E. Africa; 3 yr. 4 mo.

9. **Oesophagostomum vigintimembrum** sp. nov. Pl. IX, figs. 20, 21.

The host, a camel received at the Zoological Garden, harboured a new species of oesophagostome besides the common roundworms *Haemonchus contortus* Rudolphi 1803 and *Ostertagia mentulata* Railliet and Henry 1909.

The new species differs from other members of the genus in the position of the cervical papillae, in the number of elements of the oral leaf-crown and in measurements only. The characters of the caudal bursa of the male agree perfectly with those of oesophagostomes.

The cervical papillae are on a level with the oesophageal connection to the intestine, thus differing in their position from any known position given for the species in the four sub-genera of Railliet and Henry (1913) and Ihle (1922).

The differences between *O. vigintimembrum* and *O. venulosum* (Rudolphi 1809) are given here. *O. vigintimembrum*, as the species name indicates, has twenty elements in the external oral leaf-crown and twenty bipartite elements internal. A portion of the parts are illustrated (Pl. IX, fig. 21) to show their appearance after dissection. The cervical papillae are on a level with the

oesophageal connection to the intestine. The vulva is situated anterior to the anus, in some females at a distance equal or exceeding the distance between the anus and the tail end; this is due to a slight dorsal curve in the tail.

O. venulosum has sixteen rounded external oral leaf-elements and twice as many internal, according to H. Thornton (1924, p. 395). *O. venulosum* has eighteen elements external and eighteen elements of two roots internal, according to Railliet and Henry (1913, p. 506). *O. venulosum* has the cervical papillae behind the oesophagus, the lateral flanges are absent, and the cephalic vesicle is well developed. *O. venulosum* was found in dromedary by Mason (1915), Railliet and Henry (1913), and Ransom (1913).

There is a regular progression in numbers of oral leaf-crown elements in three species of the genus *Oesophagostomum*, *O. venulosum* has sixteen elements; *O. vigintimembrum* has twenty; while *O. columbianum* Curtice 1890 has twenty-four.

The measurements of *O. vigintimembrum* and *O. venulosum* are compared in Table IV.

Table IV.

	O. vigintimembrum sp. nov.	*O. venulosum* (Rudolphi 1819)
Dimensions:		
♂ average	8 × 0·16 mm.	11–16 mm.
♀ average	10 × 0·424 mm.	13–24 mm.
External leaf-crown elements	20	16
Internal leaf-crown elements	20 bipartite	16 (16 bipartite ?)
Submedian head papillae	Rounded	Rounded
Cephalic vesicle	Well developed and with groove	Well developed and with groove
Lateral flanges	Absent	Extend nearly length of body; very narrow
Position of cervical papillae	0·88–0·91 mm. from anterior, at level of oesophageal connection to intestine	Post-oesophageal
Buccal capsule	Ring-shaped, 74μ wide by 19μ deep	Ring-shaped
Oesophageal teeth	Six equal-spaced	—
Oesophagus	Club-shaped and 0·87 mm. from base of buccal capsule to the intestine	Club-shaped
Spicules	Equal, tips fused	Same, 1·1–1·5 mm. long, tips fused
Posterior bursal ray	Bifurcate for about half its length, each branch giving off a short outer division; inner division reaches border of bursa. Outer division half as long as inner	Same
Transverse groove	0·27 mm. from anterior end	—
Excretory pore	0·29 mm. from anterior end just posterior to transverse groove	—
Female anus	0·2–0·41 mm. from tip of tail	0·150–0·200 mm. from tip of tail
Female vulva	0·34–0·40 mm. in front of anus	0·225–0·300 mm. in front of anus

Type deposited in the Zoological Laboratory, University of Pennsylvania.

Host:

P.Z.G. No.

8922 (*c*). *Camelus dromedarius*. Intestine, few; Arabia, Egypt; 1 yr.

Family ANCYLOSTOMIDAE (Looss 1905) Lane 1917.

Genus ANCYLOSTOMA (Dubini 1843).

10. **Ancylostoma caninum** (Ercolani 1859).

The common hookworm of carnivores. These hosts also harboured species of *Toxascaris* Leiper 1907 and *Toxocara* Stiles 1905. The three pairs of ventral teeth at the oral margin are characteristic of *A. caninum*. Males 6–9 mm., females 7–13 mm. in length. Hosts:

P.Z.G. No.

2842 (*b*). *Felis rufus* (American wild cat). Small intestine, light infestation; U.S.; 1 yr. 2 mo.

3643 (*b*). *F. chans* (jungle kitten). Small intestine, few; India and N. Africa, born in the Garden; 3 mo.

3644 (*b*). *F. chans*. Duodenum, light infestation; India and N. Africa; 3 mo.

3941 (*a*). *F. pardalis* (ocelot). Small intestine, light infestation; Texas to S. America; 1 mo. 21 days.

6730. *Canis mesomelas* (black-backed jackal). Duodenum, light infestation; Africa; 1 mo. 13 days.

9125. *C. mexicanus* (American grey wolf). Small intestine, light infestation; N. America; 9 mo.

11. **Ancylostoma pluridentatum** (Alessandrini 1905).

This comparatively rare hookworm has two pairs of heavy ventral oral cutting teeth and three pairs of dorsal smaller teeth rimming the oral cavity. Males 5–6 mm.; females 7·5–8 mm. in length. Hosts:

P.Z.G. No.

3598 (*b*). *Felis pardalis* (ocelot). Stomach, few; Texas to S. America; 1 mo.

3924. *F. rufus* (American wild cat). Intestine, light infestation; U.S.; 2 mo. 13 days.

Family TRICHOSTRONGYLIDAE Leiper 1912.

Genus HAEMONCHUS Cobbold 1898.

12. **Haemonchus contortus** (Rudolphi 1803).

The common stomach worm of ruminants easily recognised by its vulvular flap, and by the assymmetrical dorsal lobe of its bursa. It was associated with whipworms in two of the hosts. (Nos. 8523 and 9150.) In a camel (No. 8922), it was associated with *Ostertagia mentulata* (Railliet and Henry 1909), recorded below, and a new species of *Oesophagostomum*, described in this paper (see pp. 203–204). Males 11–15 mm., females 20–25 mm. in length. Hosts:

P.Z.G. No.

6839. *Ovis tragelaphus* (aoudad). Stomach, medium infestation; N. Africa; 5 mo.

8523 (*b*). *O. tragelaphus*. Stomach (abomasum), light infestation; N.E. Africa; 2 mo.

8922 (*a*). *Camelus dromedarius*. Stomach (abomasum), numerous; Arabia, Egypt; 1 yr.

9150 (*b*). *C. dromedarius*. Stomach, very heavy infestation; Arabia, Egypt; 14 yr.

Genus OSTERTAGIA Ransom 1907.

13. **Ostertagia mentulata** Railliet and Henry 1909.

Railliet and Henry described this species from *Camelus bactrianus* of India and these worms fit their description exactly, showing a wider distribution.

The typical broad spicules end in movable processes and have a small dorsal accessory bursal membrane supported by rays, etc. Males 8 mm., females 10 mm. in length. Host:

P.Z.G. No.

8922 (*b*). *Camelus dromedarius*. Stomach, light infestation; Arabia, Egypt; 1 yr.

Family SYNGAMIDAE Leiper 1912.

Genus SYNGAMUS Siebold 1836.

14. **Syngamus gracilis** Chapin 1925.

A parasite of the respiratory system of birds that was found in the gizzard of a crow. This host also harboured *Porrocaecum ensicaudatum* (Zeder 1800). Males and females were coupled together and each had eight permanent teeth in the buccal capsule. The dorsal rays of the bursa are bifurcated almost to the base. Males 3·2 mm., females 9 mm. in length. Host:

P.Z.G. No.

3683 (*a*). *Corvus americanus* (common crow). Gizzard, few; N. America; 1 yr. 5 mo.

Genus CYATHOSTOMA Blanchard 1849.

15. **Cyathostoma bronchialis** (Muehling 1884).

Chapin (1925) separated the genus *Cyathostoma* Blanchard 1849 from *Syngamus* Siebold 1836 upon the ground that *Cyathostoma* has six or seven teeth in the depths of the buccal capsule and long filiform spicules; while *Syngamus* has eight or nine teeth similarly situated and small spicules. Yorke and Maplestone (1926, p. 156) make *Cyathostoma* synonymous to *Syngamus*. In this I follow Chapin.

In this species from a bear, the buccal capsule of the worm, the teeth in its depths, the spicules, the male bursa with its entire border and the bifurcated dorsal ray with branched processes, prove this to be *C. bronchialis*, its occurrence being apparently accidental as the true host is *Anser* sp. It is possible that the bottle was mislabelled. Males 10–11 mm., females 19 mm. in length. Host:

P.Z.G. No.

6493 (*b*). *Ursus beringiana* (Kamchatkan bear). Small intestine, few; Siberia; 8 yr. 3 mo.

16. **Cyathostoma americanum** Chapin 1925.

Females only that agree with the description of this species in size, shape of the head capsule and in the teeth. The capsule is 357μ wide by 228μ deep. The ova are operculated and 70μ in length. The capsule of this species differs in appearance from that of all others of the genus, and upon it largely this determination was made. This is a new host for the species. Average 39 mm. in length. Host:

P.Z.G. No.

6102. *Colinus virginianus texanus* (Texas "bobwhite" quail). —, few; Texas and southwestern U.S.; 4 yr. 3 mo.

17. **Cyathostoma coscorobae** Chapin 1925.

The species first described from a coscoroba swan in this Garden is again found in the same host and in a new host. The straight thick sides of the buccal capsule, the bifurcated dorsal ray with three terminations and the complete bursa formula identify this species. Males 8·5–12 mm., females 15–21·5 mm. in length. Hosts:

P.Z.G. No.

5216. *Coscoroba coscoroba* (coscoroba swan). Trachea, many; S. America; 3 weeks.

9226. *Plectropterus rupelli* (Rupell's spur-winged goose). Bronchus, few; N.E. Africa; 11 yr. 4 mo. (new host).

Family METASTRONGYLIDAE Leiper 1908.

Genus SYNTHETOCAULUS Railliet and Henry 1907.

18. **Synthetocaulus commutatus** (Diesing 1851).

A parasite of the respiratory system of mammals. This determination is largely based on the length of the spicules. The spicules of *Synthetocaulus sagittatus* (Mueller 1890), reported from Cervidae, are 330μ long. The spicules of *S. capillaris* (Mueller 1889), from sheep and goats, are 140–150μ long. According to Railliet and Henry (1907), those of *S. commutatus* (Diesing 1851) are 160–170μ long. Since the worms harboured by this host (No. 3049) are 148–185μ long they are placed in *S. commutatus*. Males 26 mm., females 37 mm. in length. Host:

P.Z.G. No.

3049. *Mazama hemionus* (mule deer). Trachea, few; western U.S.; 8 days.

Family DIOCTOPHYMIDAE, Railliet 1915.

Genus EUSTRONGYLIDES Jaegerskiöld 1909.

19. **Eustrongylides wenrichi** Canavan 1929.

This species, described by me in 1929 (pp. 96–97), is prevalent in water-dwelling hosts in the vicinity of Philadelphia[1]. The worms were found in the coelomic cavities, excepting those from the goose (No. 2834) which were in the proventricle. Two males 102 and 105 mm.; three females 68, 78 and 120 mm. in length.

The generic description, given by Yorke and Maplestone (1926, p. 179), states: "Parasites of glands of fore-stomach of aquatic birds." It is conceded by Jaegerskiöld (see Cram, E., 1927, p. 368) that the primary hosts are fish-eating birds and that fish are secondary hosts, although such a life-cycle has not been proven. I previously found the frog to be an aberrant host. The "Congo eel"[2] listed below is the second amphibian from which pre-adult forms

[1] Prof. David H. Wenrich, after whom it was named, had previously collected it from a frog in the vivarium of the University of Pennsylvania. Dr Henry Winsor had collected it from several fish in the Philadelphia City Aquarium and presented it to the writer.

[2] Not to be confused with Conger eel!

were gathered. These were encysted. Those from the fish were also in the pre-adult stage. Those from the goose were in the adult stage. The finding of pre-adult stages in fish and of adults in the goose furnishes additional evidence of the probable life-cycle as exemplified by Jaegerskiöld. The Canadian goose and Congo eel are new hosts. The first vial was labelled only: "Worms from fish." Hosts:

P.Z.G. No.

——(fish). Coelomic cavity; 2 males, 3 females; —; —.

2834. *Branta canadensis* (Canadian goose). Proventricle, and free in air passages; 2 males, 9 females; N. America; 13 yr.

5972. *Amphiuma means* (amphiuma). Peritoneal cavity and gastric wall; 3 females; southern U.S.; 14 yr. 7 mo.

Family OXYURIDAE Cobbold 1864.

Genus WELLCOMIA Sambon 1907.

20. **Wellcomia evoluta** (Linstow 1899).

Five porcupines harboured numerous males and females of this species. All five porcupines also harboured members of the genera *Dirofilaria* and *Dipetalonema*. *Wellcomia evoluta* has a pair of highly developed post-anal papillae supporting a membranous extension on the tail of the male. It also has one pair of conical ad-anal papillae and two pairs of ventral and sessile papillae. The male tail is a long pointed process. There is one spicule and an accessory piece. The female has the prolongation of the body usual in oxyurids and a protruding vagina. A specific character is the spiral markings in the subcuticular layer of the female tail, present only in the mid-portion of the tail; the tip is devoid of markings.

Smith, in 1908, found worms of this description in the Zoological Garden and called them *Oxyuris evaginata*. Hall (1916) placed them under von Linstow's *O. evoluta*. They became *Wellcomia evoluta* upon the splitting up of the genus *Oxyuris*. Hall's artist made an optical section in lateral view of the tail of the male from Hall's material (Hall, 1916, p. 71) which does not adequately show the male tail structures. Yorke and Maplestone (1926, p. 197, fig. 131 E) placed this illustration in their key and mistakingly labelled it "Posterior extremity of female (After Hall)." My illustrations (Pl. VIII, figs. 6, 7) show these male tail structures clearly. Males 3·5–5 mm., females 8·5–15 mm. in length. Hosts (Canadian porcupine, eastern North America):

P.Z.G. No.

2828 (*b*). *Erethizon dorsatum*. Large intestine, very numerous; 8 mo.

3183 (*c*) „ „ Caecum, many; 12 days.

3189 (*c*). „ „ Caecum, mild infestation; 14 days.

3190 (*c*). „ „ Caecum, mild infestation; 14 days.

5678 (*b*). „ „ Large intestine; very numerous; 2 yr. 11 mo.

Family HETERAKIDAE Railliet and Henry 1914.

Genus HETERAKIS Dujardin 1845.

21. **Heterakis gallinae** (Gmelin 1790).

The poultry and pheasant parasite having twelve pairs of ventral caudal papillae and a notched chitinous sucker on the tail of the male. Males 9–11 mm., females 12–13 mm. in length. Hosts:

P.Z.G. No.

3133. *Meleagris gallopavo* (eastern wild turkey). Caecum, few; eastern N. America; 1 yr. 2 mo.

2944. *Chrysolophus pictus* (golden pheasant). Caecum, heavy infestation ("tangled masses plugged caeca ducts"); China; 4 yr. 2 mo.

3317. „ „ Caecum, many; China; 4 yr. 6 mo.

3485. „ „ Caecum, few; China; 1 yr. 4 mo.

22. **Heterakis isolonche** Linstow 1906.

Another worm with twelve pairs of ventral caudal papillae, but with unalike equal spicules. The left spicule is broadly alate and asymmetrical at the tip. The right is smooth and tapering. Males 8·5 mm.; females 11·5 mm. in length. Host:

P.Z.G. No.

2849. *Chrysolophus amherstiae* (Amherst's pheasant). Caecum, heavy infestation ("caeca plugged by nemas"); China; 1 yr. 9 mo.

Family SUBULURIDAE Yorke and Maplestone 1926.

Genus SUBULURA Molin 1860.

23. **Subulura differens** (Sonsino 1890).

The lateral alae starting at the anterior end, the ten pairs of caudal papillae, which are very similar in arrangement to those of *S. distans* (Rudolphi 1809) in ventral view, spicule length and appearance, and the curved gubernaculum serve for the determination. The host is new, *vide* host list given by Cram (1927, p. 111). Measurements of length were not taken. Host:

P.Z.G. No.

3075. *Pyromelana oryx* (grenadier weaver). Small intestine, few; S. Africa; 1 day.

24. **Subulura distans** (Rudolphi 1809).

A species common in monkeys. The males have ten pairs of ventral caudal papillae. The spicules are equal. Males 14–15 mm., females 19–25 mm. in length. Hosts:

P.Z.G. No.

5042. *Macacus nemestrinus* (pig-tailed macaque). Intestine, few; Sumatra and Borneo; 17 mo.

6148. *Nyctipithecus* sp. (noisy douroucouli). Caecum, few; Brazil; 1 yr. 10 mo.

25. **Subulura jacchi** (Marcel 1857).

A worm with ten pairs of ventral caudal papillae on the male tail plus a small one on the cloacal lip. They show host-specificity. Males 5·5 mm., females 10–18 mm. in length. Host:

P.Z.G. No.
4068. *Callithrix jacchus* (common silky marmoset). Caecum, very heavy infestation; S. Brazil; 13 mo.

26. **Subulura pennula** Canavan 1929.

The same worm I previously reported (1929, pp. 80–81) from the scaled quail is harboured by Gambel's quail and is closely related to *S. brumpti* (Lopez-Neyra 1922). Ten pairs of caudal papillae; five pre-anal and ad-anal, and five post-anal, are present. Each of the males shows well-defined alae supported by the third pair of papillae from the posterior end. It is continuous with the remaining caudal alae. Males 11–12 mm., females 18–19 mm. in length. Hosts (Gambel's quail, Texas to N. Mexico):

P.Z.G. No.
3458. *Lophortyx gambeli*. Intestines, few; 1 mo.
3459. „ „ Intestines, few; 1 mo.
3460. „ „ Intestines, few; 1 mo.

Family CRUZIIDAE (Travassos 1917).

Genus CRUZIA Travassos 1917.

27. **Cruzia tentaculata** (Rudolphi 1819).

A worm that is very common in opossums and probably always associated with *Physaloptera turgida* (Rudolphi 1819) with which it was discovered originally and with which our specimens were found. *C. tentaculata* has a chitinous vestibule armed with comb-like teeth, an intestine with an anterior diverticulum, and a typically incurved conical tail in the male with nine pairs of papillae upon it. Males 7–11 mm., females 9–17 mm. in length. Hosts (common opossum, U.S.):

P.Z.G. No.
3515 (*b*). *Didelphys virginiana*. Small intestine, few; 2 weeks.
3516 (*b*). „ „ Small intestine, few; 3 mo.
7352 (*b*). „ „ Small intestine, few; 8 mo.
7585 (*b*). „ „ Duodenum, heavy infestation; 3 mo.
7842 (*b*). „ „ Caecum, heavy infestation; 5 mo.
—— (*b*). „ „ Host name recorded only.

Family ASCARIDAE Baird 1853.

Genus Ascaris Linnaeus 1758.

28. **Ascaris lumbricoides** Linnaeus 1758.

The common *Ascaris* of man, monkey, and pig. No interlabia, no alae. Two fan-like lip-pulp lobes. Male 144 × 3 mm., females 148–165 × 4 mm. in length and breadth. Hosts:

P.Z.G. No.

—. *Aloualta seniculus* (red howler monkey). Passed one male, one female; S. America.
—. *Simia satyrus* (orang utan). Passed two females; Borneo.
3279. *Macacus innuus* (Barbary ape). Lower intestine, one female; N. Africa; 9 mo.

29. **Ascaris columnaris** (Leidy 1856).

An *Ascaris* from the common skunk that agrees with Goodey and Cameron's (1923) re-description of Leidy's worm in all details. The lip-pulp is broadly flared, and dentigerous ridges are present. One female 72 mm. in length, from a Texas skunk (No. 3907), is identical with those from the common skunk, except in length. Males 60–73 mm., females 123–182 mm. in length. Hosts:

P.Z.G. No.

3907. *Mephitis mesomelas* (Texas skunk). Intestine, one female, Kansas to Texas; 3 yr. 7 mo.
4022. *M. mephitica* (common skunk). Duodenum, few; eastern U.S.; 1 yr. 10 mo.
5414. „ Duodenum, few; eastern U.S.; 8 mo.
7836. „ Small intestine, few; eastern U.S.; 1 yr. 10 mo.
8235. „ Intestine, very many; eastern U.S.; 9 mo.

30. **Ascaris hippopotami** sp. nov. Pl. IX, figs. 24, 25.

The host, a hippopotamus, rarely reaches the autopsy table. Few records of *Ascaris* from hippopotami occur in the literature. Leiper (1910), who reported two filarids and a strongylid from four hippopotami in Uganda, did not recover an *Ascaris*. This new species was passed by a baby hippopotamus that has since grown to adulthood in the Garden. The description is based on one female 282 mm. in length by 3–4 mm. in breadth. Its kinship with *A. lumbricoides* Linnaeus 1758 is evident, the cervical alae being absent. The vulva is 100 mm. from the anterior end, and leads into a posteriorly directed vagina, from which arise two uterine tubes. All three lips have dentigerous ridges.

There are no interlabia. The dorsal lip is broader than long. It is broadest at the base, upon which two double papillae are situated near the outer border. The two subventral lips differ in shape from the dorsal. They are square. The one double papillae upon the subventral lip is at one side of the median line. The lip-pulp in all three lips have two anteriorly projecting irregular prominences which bulge outwards and have bipartite processes upon their broadest part directed toward the median line of the lip. They look like the lip-pulp of the bird ascarid *Porrocaecum depressum* (Zeder 1880). The anterior

bipartite process is the smaller and the median the larger of the two. Internal to these lip-pulp projections is a median lobe, rounded anteriorly and visibly projecting beyond the saddle joining the two main lobes. The saddles of the dorsal and subventral lips differ. It is cut deep and has a rounded base in the dorsal lip; it is cut short of the centre and is broadly **V**-shaped in the subventral lips. The apex of the **V** in the subventral lips is at the base of the median round lobe. The bases of the lip-pulp are symmetrical in the dorsal lip while the bases are asymmetrical in the subventral lips. Male unknown.

Type deposited in the Zoological Laboratory, University of Pennsylvania. Host:

P.Z.G. Date.
21. iii. 19. *Hippopotamus amphibius*. Passed one female; Africa; —.

Genus Toxocara Stiles 1905.

31. **Toxocara mystax** (Zeder 1800).

The common *Ascaris* of Felidae. *T. mystax* has a probular male tail and abruptly inturning cervical alae. It occurred singly and with hookworms several times. Males 44–54 mm., females 60–78 mm. in length. Hosts:

P.Z.G. No.
3369. *Felis rufus texensis* (spotted lynx). Stomach, few; Texas to California; 2 mo.
3598 (*c*). *F. pardalis* (ocelot). Intestine, light infestation; Texas to S. America; 1 mo.
3616. *F. chans* (jungle kitten). Jejunum, mild infestation; India and N. Africa; 14 mo.
3643 (*a*). „ Small intestine, mild infestation; born in the Garden; 3 mo.
3644 (*a*). „ Small intestine, mild infestation; India and N. Africa; 3 mo.
3933. *F. canadensis* (Canada lynx). Intestine, light infestation; western N. America; 6 mo.
7008. *F. rufus* (American wild cat). Intestine, heavy infestation; U.S.; 22 days.

32. **Toxocara canis** (Werner 1782).

The common *Ascaris* of Canidae and related hosts. Its cervical alae are straight and long. It has a probular male tail and short spicules. Males 65–90 mm., females 75–110 mm. in length. Hosts:

P.Z.G. No.
3180. *Canis mexicanus* (American grey wolf). Intestine, few; N. America; 2 yr. 10 mo.
3584. „ „ Stomach, one male only; N. America; 3 mo.
4052. „ „ Duodenum, several; born in the Garden; 6 mo.
4642. *C. c. a. scotti* (Scott's grey fox). Intestine, several; S. Cal., Arizona, New Mexico; 30 mo.
4764 (*a*). *C. dingo* (dingo dog). Intestine, many; Australia; born in the Garden; 4 mo. 25 days.
6949. *C. vulpes pennsylvanicus* (American red fox). Intestine, several; N. America, 8 mo.

Genus Toxascaris Leiper 1907.

33. **Toxascaris leonina** (Linstow 1902).

The common *Ascaris* of Carnivora. This worm has the lobules of the lip-pulp bilobed and enlarged at the extremities. Males 33–61 mm., females 46–91 mm. in length with the exception of two females from an unknown host

listed last here. These were 200 × 4·25 mm. and 215 × 4·5 mm. in length. Hosts:

P.Z.G. No.

2842 (*a*). *Felis rufus* (American wild cat). Small intestine, mild infestation; U.S.; 1 yr. 2 mo.
2901. „ „ Rectum, one female only; U.S.; 2 mo.
2981. *Cynaelurus jubatus* (cheetah). Stomach and intestine, few; Asia and Africa; 3 mo.
3112. *Lycaon pictus* (Cape hunting dog). Intestine, mild infestation; S. Africa; 7 mo.
3204. *F. concolor* (puma). Stomach and duodenum, mild infestation; N. and S. America; 2 mo. 10 days.
3506. *F. tigris* (Siberian tiger). Intestine, few; Asia; 6 yr. 8 mo.
3640. *F. concolor* (puma). Intestine, few; born in the Garden; 4 mo.
3641. *F. catus* (European wild cat). Intestine, few; Europe and western Asia; 13 mo.
4724. *F. leo* (lion). Intestine, few; born in the Garden; 10 mo. 13 days.
4764 (*b*). *Canis dingo* (dingo dog). Intestine, many; born in the Garden; 4 mo. 25 days.
7617. *F. leo* (lion). Intestine, heavy infestation; Africa and S. Asia; 9 yr. 3 mo.
8886. *C. latrans* (prairie wolf). Small intestine, very heavy infestation; western N. America; 20 days.
——. *Canis* sp. (dog). —, several; —; —.

34. **Toxascaris transfuga** (Rudolphi 1819).

The common *Ascaris* of Ursidae. The lip-pulp of this worm is like the preceding ascarid, but it has short spike-like spicules and sixty-two irregular pairs of discernible caudal papillae. Males 65–125 × 1·25–2·25 mm., females 118–262 × 1·75–4·5 mm. in length and breadth. It is interesting to note that, according to the protocol, the grizzly bear (No. 8588) "died due to toxemia from ascarids." Hosts:

P.Z.G. No.

6493 (*a*). *Ursus beringiana* (Kamchatkan bear). Intestine, few; Siberia; 8 yr. 3 mo.
7370½. *U. americanus* (black bear). Intestine, many; U.S.; died a cub.
8588. *U. horribilis* (grizzly bear). Intestine, extra heavy infestation; western N. America; 1 yr.
8967. *Melursus ursinus* (sloth bear). Intestine, several; India; 9 yr. 3 mo.
——. —— (bear). Passed, after santonin, one female 205 mm. long. —; —.

Genus LAGOCHILASCARIS Leiper 1909.

35. **Lagochilascaris turgida** (Stossich 1902).

This worm is found in *Didelphys crassicaudata* and *D. virginiana*. The strongly developed cuticular ring around the base of the lips and the interlabia present are characteristic. No measurements made. Host:

P.Z.G. No.

2805. *Didelphys virginiana* (common opossum). Stomach, few; U.S.; 1 mo.

Genus PARASCARIS Yorke and Maplestone 1926.

36. **Parascaris equorum** (Goeze 1782).

These worms have deep-fissured lips and interlabia. Found in a zebra which also harboured *Strongylus equinus* Mueller 1780. All females, 17–27 mm. in length. Host:

P.Z.G. No.

3033 (*b*). *Equus zebra* (mountain zebra). Intestine, very heavy infestation; S. Africa; 4 mo.

Genus OPHIDASCARIS Baylis 1921.

37. **Ophidascaris filaria** (Dujardin 1845).

An ascarid of snakes. The lips are grooved at the base and the lip-pulp is multiradiate. The antler of the lip-pulp is directed posteriorly as illustrated by Baylis (1921, p. 413). Interlabia and dentigerous ridges are present. Males 90 mm., females 95–110 mm. in length. Host:

P.Z.G. No.
7331. *Python spilotes* (diamond snake). Stomach, large masses; Australia and New Guinea; 3 mo.

Genus ASCARIDIA Dujardin 1845.

38. **Ascaridia hermaphrodita** (Froelich 1789).

This adds two new host records for this worm. It was previously found in *Crysotis festiva*. The males readily fit the descriptions given by Skrjabin (1917, p. 465) and Cram (1927, p. 80). There are six pairs of pre-anal papillae, none of which is anterior of the chitinous sucker, and seven pairs irregularly distributed posteriorly; or a total of thirteen pairs. The spicules are equal, cross-striated and with a unilateral wing. Skrjabin had only one male. Cram, in her compilation, points out that many authors differ as to the dimensions of the male. Schneider (1866) indicated that the males are 29 mm. in length; Skrjabin gives 19 mm. as the length. The males before me vary in size: five measured 19·5, 33, 37, 38 and 42 mm. in length respectively, by 1·1 mm. in breadth.

Neither Skrjabin nor Cram gives an adequate description of the female. Cram (1927, p. 80) writes: "Female 35 mm. long. No further description." I have examined a dozen females.

These females measure 40–42·5 mm. in length by 1·27 mm. in breadth, and have the appearance of the larger males. There are three lips of equal size; each is three-lobed; the side lobes are of the same size as the anterior one. The body is finely striated transversely. The striae are 18μ apart. The vulva is almost in the middle of the body. It is 20 mm. from the anterior end in a 41 mm. worm, and 20·5 mm. from the anterior end in a 42 mm. worm—an anterior-posterior ratio of 20/21. It is salient and readily detected by the naked eye. The vagina branches into two opposed uteri. The anus is 0·927 mm. from the posterior end in a 40 mm. worm, and 1·07 mm. from the posterior end in a 42 mm. worm. The tail of the female is digitiform and ends in a short sharp conical spike. The spike is 45μ long. The ova in the vagina are in the morula stage and measure 76μ × 48μ. Hosts:

P.Z.G. No.
3427. *Palaeornis torquatus* (ring-necked parakeet). Intestine, several; Malacca to Borneo; 8 yr. 5 mo.
3987. *Chrysotis amazonica* (orange-winged amazon). Intestine, mild infestation; S. America; 4 yr. 10 mo.

39. **Ascaridia lineata** (Schneider 1866).

A common parasite of domestic fowl. There are ten pairs of male caudal papillae and one unpaired on the posterior rim of the sucker. Males 44–54 mm., females 71–76 mm. in length. Host:

P.Z.G. No.
—. *Gallus domesticus*. Intestine, many; U.S.; —.

40. **Ascaridia stroma** (Linstow 1899) Railliet and Henry 1914.

A demoiselle crane is a new host for this species. As illustrated by me (1929, Pl. IV, fig. 8) the male, 45 mm. in length, has twelve pairs of papillae (not ten as stated by Cram, 1927, p. 99), and it undoubtedly fits von Linstow's species, because the ad-anal pair and the two pairs directly posterior to them have large bases. It is the only species in the genus that has arrow-shaped head membranes. This one has an asymmetrical pre-anal pair of papillae and one ventral pair at the base of the ad-anals. It is believed that these were overlooked heretofore, as all other points are in agreement. Host:

P.Z.G. No.
7507. *Anthropoides virgo* (demoiselle crane). Small intestine, one male; S. Europe and Asia, N. Africa; 2 yr. 9 mo.

Family HETEROCHEILIDAE Railliet and Henry 1915.

Genus PORROCAECUM Railliet and Henry 1912.

41. **Porrocaecum angusticolle** (Molin 1860).

Worms of the genus *Porrocaecum* have an anterior intestinal caecum and an oblong ventriculus. The posteriorly directed appendix is absent. *P. angusticolle* is a member of this group. It has its lip-pulp two-lobed and joined by a saddle. These are the first North American records of it. Males 42–55 mm., females 54–90 mm. in length. Hosts:

P.Z.G. No.
7111. *Buteo borealis* (red-tailed buzzard). Duodenum, few; eastern N. America; 5 mo.
7846. „ „ Duodenum, many; eastern N. America; 18 days.
7975. „ „ Intestine, few; eastern N. America; 6 mo.
7739. *Helotarsus ecaudatus* (bateleur eagle). Intestine, one female; Africa; 4 yr. 3 mo.

42. **Porrocaecum depressum** (Zeder 1800).

A large-lipped worm of birds. The lip-pulp projects in bipartite processes and a large rounded median lobe. Interlabia small and sharp. A new host. Males 88–96 mm., females 122–128 mm. in length. Host:

P.Z.G. No.
6105. *Spermophila luctuosa* (black finch). Intestine, several; northern S. America; 21 mo.

43. **Porrocaecum ensicaudatum** (Zeder 1800).

A worm characterised by an almost rudimentary caecum; in addition to the dentigerous ridges and interlabia present the very wide lips have winged processes on the distal side of the lip-pulp. A new host and the first North

American record of it. One host (No. 3683) also harboured *Syngamus gracilis* Chapin 1925. No males; females average 70 mm. in length. Hosts:

P.Z.G. No.
3358. *Corvus americanus* (common crow). Stomach, duodenum, few; N. America; 8 mo.
3683 (*b*). „ „ Stomach, gizzard, few; N. America; 17 mo.

44. **Porrocaecum reticulatum** (Linstow 1899).

The lip characters and the male tail of this bird parasite agree with von Linstow's description as given by Cram (1927, p. 142). The dorsal lip has two rounded converging projections anteriorly; the male tail has a finger-like end with the papillae arranged as follows: one pair post-anal, larger, above the constriction; and five pairs pre-anal. Two males in three broken pieces—11, 18, and 26 mm. in length. A new host and a new distribution. Host:

P.Z.G. No.
8157. *Nyctanassa violacea* (yellow-crowned night heron). Ileum, pieces; southern U.S. to S. America; 3 mo.

45. **Porrocaecum serpentulus** (Rudolphi 1809).

A worm with large ear-shaped interlabia two-thirds the size of the large lips, and anterior bipartite lip-pulp projections. Common in *Ardea*. *Tetrapteryx* is a new host genus for it. Male 60 mm., female 120 mm. in length. Hosts:

P.Z.G. No.
2487. *Ardea tricolor ruficollis* (Louisiana heron). Intestine, four; southern U.S.; 6 mo.
6291. *Tetrapteryx paradisea* (Stanley crane). Duodenum, one large; S. Africa; 3 yr. 3 mo.

46. **Porrocaecum spirale** (Rudolphi 1795).

The finger-like pulp projections of the six-sided lips, the dentate band prominently projecting anteriorly, the six pairs of pre-anal papillae, the one double pair of papillae posterior to the cloacal aperture and the two pairs on the conical tail appendage are prominent characteristics of this species. They are found in owls, but heretofore reported from Europe only. This is a new host genus and distribution record for it. Male 50 mm., female 70 mm. in length. Host:

P.Z.G. No.
8757. *Aluco pratincola* (barn owl). Pylorus to caecum, many; U.S., Mexico, Cuba; 2 mo. 15 days.

Genus Contracaecum Railliet and Henry 1912.

47. **Contracaecum microcephalum** (Rudolphi 1809).

The genus *Contracaecum* has a posteriorly directed appendix in addition to the intestinal caecum. *C. microcephalum* is distinguished in that it has a shirred appearance to the cuticle directly behind the head and ear-shaped projections upon the anterior of the lips. The two large double papillae on the dorsal lip, the one large double papillae on each of the others and the interlabia, incised at the summit as high as the lips, are morphological features of importance

employed to determine this species. The host harboured two females 11·5 and 22 mm.; and one male 6·5 mm. in length. The worms are immature. Host:

P.Z.G. No.
3603. *Nycticorax nycticorax naevius* (common night heron). Proventricle, few; N. and S. America; —.

48. **Contracaecum micropapillatum** (Stossich 1890).

This worm has laterally projecting ear-like processes sharply pointed. The interlabia are well developed, rounded and split anteriorly. The collar-like fold of the cuticle behind the head is shirred heavier than in *C. microcephalum*. This is a new host. Males 22 mm., females 33 mm. in length. Host:

P.Z.G. No.
——. *Spatula clypeata* (shoveller duck). Intestine, few; northern hemisphere; —.

Genus HABRONEMA Diesing 1861.

49. **Habronema incerta** (Smith 1908).

The parasite that once caused an enzoötic among parakeets in this Garden is still to be found in scattered hosts. The caudal papillae of this worm are in a small group at the end of the tail, one is on the cloacal rim, and six pedunculated pairs support the caudal alae. The cloacal lip papilla is at one corner of the anterior lip. The spicules are very unequal. Males 5·5–9 mm., females 8–13 mm. in length. New host records:

P.Z.G. No.
6025. *Eurypyga helias* (sun bittern). Proventricle, few; Central and S. America; 6 mo.
6357. *Schizorhis concolor* (grey louracou). Imbedded in ulcer in pylorus, one small female; S. Africa; 11 mo.
3483. *Dendrocitta himalayensis* (Himalayan tree pie). Proventricle, one female; N. India; 12 yr. 5 mo.
9129. *Cyanops lineata* (linneated barbet). Proventricle, many; India; 3 mo.

50. **Habronema unilateralis** (Molin 1860).

Worms of this species were found in three toucans. They are similar to *H. incerta* (*v. supra*), but differ in the pedunculated papillae and arrangement of the small group of papillae at the tip of the tail. The spicules are very unequal in length. The one papilla on the cloacal lip is situated upon the median line. Males 6–9 mm., females 8–12 mm. in length. Hosts:

P.Z.G. No.
2416. *Rhamphastos carinatus* (sulphur-breasted toucan). Proventricle, few; Mexico; 14 mo.
5995. *R. ambiguus* (doubtful toucan). Proventricle, few; Columbia to Peru; 3 yr. 8 mo.
8334. *R. toco* (toco toucan). Oesophagus, proventricle, gizzard, and duodenum, very heavy infestation; Guiana, Brazil; 6 yr. 7 mo.

Genus HADJELIA Seurat 1916 *c.*

51. **Hadjelia lhuillieri** Seurat 1916.

A vulture harboured one female worm of this species. It has two trilobed lateral lips and a scalloped lobular collar encompassing them. Alae absent.

Vulva anterior. Male unknown. The female measured 18·5 mm. in length. The new host (*v. infra*) has the same distribution as *Caccabis petrosa* the type host. Host:

P.Z.G. No.
8314. *Gyps ruppelli* (Ruppell's vulture). Proventricle, one; N.E. Africa; 10 mo.

Family ACUARIDAE Seurat 1913.

Genus ACUARIA Bremser 1811.

52. **Acuaria (Dispharynx) crassissima** (Molin 1860).

One female worm was found in a toucan. Male unknown. Female measured 13 mm. in length. The cutaneous cordons on the anterior end are recurrent along about a third of the body-length, but do not anastomose. A single spined papilla lies between and just anterior to the ends of the thick cordons. At the anterior extremity the lateral cordons join at the base of the two large papilliform lips. Vulva posterior. The host (*v. infra*) also harboured *H. incerta* (Smith 1908). Host:

P.Z.G. No.
2416. *Rhamphastos carinatus* (sulphur-breasted toucan). Proventricle, one; Mexico; 14 mo.

Genus COSMOCEPHALUS Molin 1858.

53. **Cosmocephalus obvelatus** (Creplin 1825).

A worm from a gull. It has anastomosing cordons heavily scalloped on the inner edge and a bicuspid spined cervical papilla at the level of the origin of the muscular oesophagus. The two groups of four pairs each of caudal papillae anterior and posterior to the cloacal aperture in the male, and the single pair near the tail end, verify this determination. The spicules are very dissimilar and unequal. Males 7·5 mm., females, 9–13·5 mm. in length. Host:

P.Z.G. No.
2520. *Larus argentatus smithsonianus* (herring gull). Proventricle, several; N. America; 3 yr. 9 mo.

Family GNATHOSTOMIDAE Railliet 1895.

Genus GNATHOSTOMA Owen 1836.

54. **Gnathostoma spinigerum** Owen 1836.

An interesting worm, the head bulb and whole anterior part of which is covered with spines. The anterior spines bear many points, but diminish to a single point posteriorly. Male with four pairs of pedunculated papillae and two smaller pairs ventrally located on the blunt tail end. Parasites usually of carnivorous mammals. The species *G. spinigerum* is new in the opossum although *G. turgidum* Stoss. 1902 occurs in *Didelphys azare*. This is one of three species found in the opossum (No. 7585) listed below. The same worm was one of four

roundworm species harboured by the ocelot (No. 3598). Males 19·5 mm., females 40 mm. in length. Hosts:

P.Z.G. No.
7585 (*c*). *Didelphys virginiana* (opossum). Stomach, one female and tail of male; U.S.; 3 mo.
3598 (*a*). *Felis pardalis* (ocelot). Stomach, several; Texas to S. America; 1 mo.

Family PHYSALOPTERIDAE Leiper 1908.

Genus PHYSALOPTERA Rudolphi 1819.

55. **Physaloptera antarctica** von Linstow 1899.

A stomach worm from a monitor. The lips have a recurved single cuneiform tooth and a spike-like split external tooth. The spicules are unequal and the post-cloacal papillae are unevenly spaced. Four uteri are present. Found in the type host. Males only, 22–29 mm. in length. Host:

P.Z.G. No.
6837. *Varanus varius* (spotted monitor). Stomach and oesophagus, few males; Australia; —.

56. **Physaloptera galinieri** Seurat 1914.

These worms have a large conspicuous tripartite inner tooth and a knobbed outer tooth slightly recurved. The male spicules are short. Two uteri are present. The male has five pairs of stalked papillae, the fourth ventral pair posterior to the cloacal aperture are elevated. Originally found in eagle. Males 14·5–16·5 mm., females 17–23 mm. in length. Host (new):

P.Z.G. No.
6013. *Lophoceros flavirostris* (yellow-billed hornbill). Stomach, few; E. Africa; 4 mo. 15 days.

57. **Physaloptera multiuteri** Canavan 1929.

This parasite, previously described by me (1929, p. 90) from *Ateles ater*, is likewise found in *Ateles geoffroyi*, only one female specimen was found in this host. It has the outer tooth markedly truncate and the inner tooth lower, semi-membranous and tripartite. The anterior end is attenuated. Twelve uteri arise from the outer edges of the egg chamber. Host:

P.Z.G. No.
6904. *Ateles geoffroyi* (black-handed spider monkey). Stomach, one female; Central America to Columbia; 1 yr. 5 mo.

58. **Physaloptera papillotruncata** Molin 1860.

The arrangement of the ventral bursal papillae, the presence of two uteri, the character of the teeth, the total length and the equality and similarity of the spicules convince the writer that the worms should be placed under the species *P. papillotruncata* as given by Ortlepp (1922, p. 1016). Molin's original material came from *Myrmecophaga jubata* in Brazil. This worm from American badger

is the same species as harboured by the Brazilian anteater. Males 22–28 mm., females 28–48 mm. in length. Hosts (American badger, western N. America):

P.Z.G. No.

3150. *Taxidea taxus*. Stomach, many; 3 mo.
3167 (*b*). „ „ Stomach, few; 3 mo.
3254. „ „ Stomach and duodenum, few; 7 mo.
3299 (*b*). „ „ Stomach and caecum, many; 5 mo.

59. **Physaloptera tumefaciens** Henry and Blanc 1912.

This worm, from a sooty mangaby, has been reported hitherto only from the Macaque monkey. The number and origin of the uteri in the female, the shape and size of the labial teeth, the spicules, and the papillar distribution on the tail of the male, are as in *P. tumefaciens*. Pairs three, four, and five, of the ventral sessile papillae are all anterior to the middle of the tail and equidistant from each other. Males 31–37 mm., females 40–48 mm. in length. Host:

P.Z.G. No.

2485. *Cercocebus fuliginosus* (sooty mangaby). Stomach, few; W. Africa; 4 mo.

60. **Physaloptera turgida** (Rudolphi 1819).

P. turgida, the common stomach worm of opossums, was encountered twenty-five times. Six times it was found with *Cruzia tentaculata* (Rudolphi 1819) and once with *C. tentaculata* and *Gnathostoma spinigerum* Owen 1836. In the two badgers (Nos. 3167 and 3299) there were two species of *Physaloptera* present; one of them proved to be this species, the other *P. papillotruncata* Molin 1860. *P. turgida* is readily recognised by the alignment of the two pairs of sessile caudal papillae in a group near the last third of the tail of the male and the eight or nine uteri in the female. Males 23–43 mm., females 33–70 mm. in length. Hosts:

P.Z.G. No.

2262. *Didelphys virginiana* (common opossum). Stomach, numerous; U.S.; 9 mo.
2354. „ „ Stomach, numerous; U.S.; 9 mo.
2468. „ „ Stomach, one female; U.S.; 14 mo.
2519. „ „ Stomach, many; U.S.; 2 mo.
2544. „ „ Stomach, few; U.S.; 1 yr. 4 mo.
2848. „ „ Stomach, few; U.S.; —.
3169. „ „ Stomach, few; U.S.; 4½ mo.
3167 (*a*). *Taxidea taxus* (American badger). Stomach, few; western N. America; 3 mo.
3299 (*a*). „ „ Stomach and caeca, many; western N. America; 5 mo.
3515 (*a*). *D. virginiana*. Stomach, many; U.S.; 2 weeks.
3516 (*a*). „ Stomach, many; U.S.; 3 mo.
3522. „ Stomach, many; U.S.; 9 days.
3526. „ Stomach, many; U.S.; 2 mo. 20 days.
3614. „ Stomach, fairly numerous; U.S.; 4½ mo.
3622. „ Stomach, many; U.S.; 18 days.
3958. „ Stomach, many; U.S.; 5 mo.
4303. „ Stomach, many; "three sluggish ulcers; into one of them a worm was fastened"; U.S.; 2 mo.
4649. „ Stomach, few; U.S.; 27 days.

P.Z.G. No.		
4763.	*D. virginiana*	Stomach, few; U.S.; 7 days.
4819.	,,	Stomach, few; "imbedded in mucosa"; U.S.; 6 days.
4875.	,,	Stomach, large numbers; U.S.; 5 mo. 12 days.
5994.	,,	Stomach, "several firmly attached to mucosa"; U.S.; 3 mo. 25 days.
7352 (*a*).	,,	Stomach, few; U.S.; 8 mo.
7468.	,,	Oesophagus, stomach, and duodenum, many; U.S.; 4 mo.
7485.	,,	Stomach, few; U.S.; 6 mo.
7486.	,,	Stomach, few; U.S.; 7 mo.
7585 (*a*).	,,	Stomach and duodenum, "duodenum tightly packed with round-worms"; U.S.; 3 mo.
7842 (*a*).	,,	Stomach, many "attached to ulcers"; U.S.; 5 mo.
7860.	,,	Stomach, many "attached to ulcers"; U.S.; 3 mo.
7945.	,,	Oesophagus, mouth, and stomach, very heavy infestation; U.S.; 1 mo.
No number	,,	Stomach (?).
,,	,,	Stomach (?).

Family TETRAMERIDAE Travassos 1914.

Genus TETRAMERES Creplin 1846.

61. **Tetrameres fissispina** (Diesing 1861).

The genus *Tetrameres* exhibits extraordinary sexual dimorphism. The females are greatly distended in the middle of the body, the males filiform throughout. They are parasites of the proventricle of birds. The three males harboured by the goose (*v. infra*) have posteriorly directed simple spines along the median and lateral lines of the body, as well as a lateral ala, which flares slightly, behind the three lips. There is a characteristically long, cleft, or bifid spine at the cephalic end of this ala. The spicules are unequal. Three males 6 mm. in length. Host:

P.Z.G. No.	
7548.	*Anseranas semipalmata* (black and white goose). Proventricle, three; Australia, Tasmania; 1 yr. 11 mo.

Family FILARIIDAE (Cobbold 1864) Claus 1885.

Genus DIROFILARIA Railliet and Henry 1911.

62. **Dirofilaria subcutanea** (Linstow 1899).

This species, with six pairs of ventral caudal papillae, symmetrically arranged anterior to the male cloacal aperture, was found four times in its normal host. The spicules average 0·128 and 0·458 mm. in length respectively, hence having a ratio of 4 : 1. See Pl. IX, fig. 23. Males 49 mm., females 159 mm. in length. Hosts (Canadian porcupine, eastern N. America):

P.Z.G. No.			
3183 (*a*).	*Erethizon dorsatum*.	Peritoneum, few; 12 days.
3189 (*a*).	,,	,,	Peritoneum, three; 14 days.
3190 (*a*).	,,	,,	Peritoneum, several; 14 days.
3193 (*a*).	,,	,,	Peritoneal cavity, a dozen; 15 days.

63. **Dirofilaria repens** Railliet and Henry 1911.

I believe this is the first report of *Dirofilaria repens* from a porcupine. The difference between Railliet and Henry's measurements, etc., of this dog parasite and the measurements of the lot I examined lies in the spicule length ratio only. Railliet and Henry give a ratio of 2·5 : 1 whereas these approximate 3 : 1. However, the accompanying table of comparison (Table V) shows that the larger spicule according to their description attains a maximum length of 0·59 mm., the smaller a maximum length of 0·20 mm. This is approximately a 3 : 1 ratio.

Table V. (*Dirofilaria repens.*)

	Host: Dog (Railliet & Henry's measurements)	Host: Porcupine (Canavan's measurements)
	Male	
Dimensions:		
Length	48–70 mm.	50–65 mm.
Breadth	0·35–0·45 mm.	Av. 0·4 mm.
Distance from cloaca to posterior end	0·075 mm. (66–85)	0·07 mm.
Form of large papillae	Oblong	Oblong (in lateral view)
Number and arrangement of large papillae	Asymmetrical; 2–4 on one side (pre-anal), 5 or 6 on the other of which one ad-anal or slightly post-anal	Asymmetrical (see Pl. IX, fig. 22); 4 on left side (pre-anal), 5 on right, one of which is ad-anal
Spicule length:		
Larger	0·465–0·59 mm.	0·29–0·31 mm.
Smaller	0·185–0·206 mm.	0·096–0·11 mm.
Ratio, larger to smaller	2·5 : 1	3 : 1
	Female	
Dimensions:		
Length	100–170 mm.	170 mm.
Breadth	0·46–0·65 mm.	Av. 0·5 mm.
Distance of vulva from anterior end	1·15–1·6 mm.	1·28 mm.
Distance of anus from posterior end	0·05–0·09 mm.	0·1 mm.
Size of embryo or ova	Embryo 0·3–0·36 × 0·006 mm.	—

Host:

P.Z.G. No.

3194 (*a*). *Erethizon dorsatum* (Canadian porcupine). Peritoneal cavity and subcutaneous, few; eastern N. America; 16 days.

Genus Setaria Viborg 1795.

64. **Setaria labiato-papillosa** (Alessandrini 1838).

One female of this filarid species that has a chitinous peribuccal ring, prolonged anteriorly to form notched lip-like prominences, was found in a yak. The posterior end terminates in a knob-like prominence, composed of a group of papillae, and a pair of lateral appendages which give the tail a trifid

appearance. This is the second time this species has been found in a yak in the Zoological Garden. Length 62 mm. Host:

P.Z.G. No.
5383 (*b*). *Poephagus grunniens* (yak). Intestine, one female; born in the Garden; 3 yr. 6 mo.

Genus DIPETALONEMA Diesing 1861.

65. **Dipetalonema diacantha** (Molin 1858).

A worm occurring commonly in the Canadian porcupine. It is readily recognised by the bifid female tail, and by the shape of the dissimilar, unequal, winged spicules in the male. This species was found in five cases in association with another filarid genus and in two cases with an oxyurid genus (Table I). Males 35–68 mm., females 69–92 mm. in length. Hosts (Canadian porcupine, eastern N. America):

P.Z.G. No.

2773.	*Erethizon dorsatum*.		Peritoneum, many; 10 mo.
2828 (*a*).	,,	,,	Peritoneum, few; 8 mo.
3059.	,,	,,	Peritoneum, medium infestation; 3 mo.
3129.	,,	,,	Peritoneal cavity, mild infestation; 4 mo.
3183 (*b*).	,,	,,	Peritoneum, medium infestation; 12 days.
3189 (*b*).	,,	,,	Peritoneum, three; 14 days.
3190 (*b*).	,,	,,	Peritoneum, several; 14 days.
3193 (*b*).	,,	,,	Peritoneum, heavy infestation; 15 days.
3194 (*b*).	,,	,,	Peritoneum, light infestation; 16 days.
5678 (*a*).	,,	,,	Muscles, blood, larva, medium infestation; 2 yr. 11 mo.
6290.	,,	,,	Peritoneum, blood, four; 9 days.

66. **Dipetalonema gracile** (Rudolphi 1809).

The common threadworm of Brazilian monkeys. The unequal spicules, the papillar arrangement, the twisted tail of the male, and the position of the vulva at the middle of the oesophagus in the female place it readily. Males 74 mm., females 189–219 mm. in length. Hosts:

P.Z.G. No.
5729. *Lagothrix infumatus* (reddish woolly monkey). Peritoneal cavity, few; Amazon valley, S. America; 10 mo.
6451. *Cebus capucinus* (weeper cebus). Peritoneum, one female; Brazil; 2 yr.
8801. *Midas ursulas* (Tamarin marmoset). Mesentery, three found; Lower Amazon in Brazil, near Peru; 1 yr.

Genus DIPLOTRIAENA Railliet and Henry 1909.

67. **Diplotriaena tricuspis** Fedtschenko 1874.

O. von Linstow's (1899, p. 25) first host for *D. tricuspis* was *Gracula grisea* which = *Acridotheres ginginianus*, the Indian mynah, from whence some of these (No. 3311) were taken at the Zoological Garden.

D. tricuspis is differentiated from the other members of the genus by the great length of the female, the unequal, comparatively long spicules, the relatively short tridents for so long a female, and the fact that the divided or posterior part of the oesophagus expands to three times the width of the

anterior part. The tridents in the material I have from the mynah (No. 3311) measure 0·143–0·171 mm. in length; the spicules 0·572 and 2·288 mm. in length; the oesophagus begins to bulge 0·643 mm. from the anterior end; the vulva is 0·614 mm. from the anterior end, agreeing with the species descriptions given by Boulenger (1920 and 1928). Males 36–75 mm., females 49–200 mm. in length.

The tridents in the specimens from the jay (No. 2824) are 0·114 mm. in length; the cuticle is smooth; the posterior part of the oesophagus expands to thrice the width of the anterior part at a point 0·271 mm. from the oral end; the double curved small spicule is 0·643 mm. in length, while the long one is 1·073 mm. in length. Males 73 mm., females 157 mm. in length. Hosts:

P.Z.G. No.

2824. *Cyanocorax affinis* (Columbian jay). Thoracic cavity, many; Panama and Columbia; 3 yr. 8 mo.

3311. *Acridotheres ginginianus* (Indian mynah). Abdominal air sacs and intestine, few; N. India; 1 yr. 11 mo.

5380. *Graculipica melanoptera* (black-winged mynah). Body cavities, few; Java; 6 yr. 7 mo.

68. **Diplotriaena** sp. (immature ?).

Two worms that show exceptions to established species are placed under this designation.

One female worm, 27 mm. long, from a bunting (No. 3137), appears to be *D. artemissiana* Schmerling 1925. It has smooth, slender, and regular tridents, 0·143 mm. long. They project beyond the anterior end. The cuticle is smooth. The posterior part of the oesophagus becomes twice as broad as the anterior part at a point 0·243 mm. from the anterior end.

A male, 25 mm. long, and a female worm, 73 mm. long, from the diamond sparrow (No. 6897), have their irregularly shaped tridents 0·114–0·128 mm. long. They do not protrude beyond the anterior end. The cuticle is not ringed nor striated. The oesophagus appears not to be divided nor bulging. The vulva is 0·414 mm. from the anterior end and the spicules are short—0·643 and 0·357 mm. in length. Schmerling's (1925) key would place this worm close to *D. obtusa* (Rudolphi 1802) because of the length of the tridents and the total length of the female. They appear to be *D. tridens* (Molin 1858) because of the shortness of the spicules, the character of the oesophagus, and the character of the cuticle and the tridents. Hosts:

P.Z.G. No.

3137. *Emberiza flaviventris* (yellow-bellied bunting). In loose tissue of upper thorax, one female; Africa; 2 yr. 2 mo.

6897. *Petronia superciliaris* (diamond sparrow). Coelomic cavity; one male and one female; S.E. Africa; 2 yr. 2 mo.

69. **Diplotriaena bifidus** sp. nov. Pl. IX, figs. 14–19.

This easily recognised genus now contains over twenty species. According to Boulenger (1928), "The species are notoriously difficult to make out. It has

become almost a habit to describe as new any *Diplotriaena* which does not readily conform with one of the better known species, or which has been obtained from an unusual host." This is primarily due to the failure of many to avail themselves of the literature on this group in the first place, and the inadequacy of the descriptions in the second place. There are times, as for instance in the case of the new species described below, when all of the literature available to the individual working on the group does not throw any light on the correct species designation or leaves a doubt as to the accuracy of allotting the specimens at hand to some established species. The writer in this case follows the axiom of Prof. Stiles who said, "When in doubt as to the accuracy of allotting the specimens at hand to some established species it is better to erect a new species[1]."

What appears to be a distinct species of *Diplotriaena* hitherto undescribed was gathered from two species of jays.

The species of the genus *Diplotriaena* are divided into two groups—those with an enlarged posterior oesophagus and a double curve in the shorter spicule, and those with the oesophagus not enlarged and having a single curve in the shorter spicule. The specimens under consideration have a common basis for comparison with members of the first group. A distinctive characteristic, however, rests in the longest member of the chitinous trident being cleft distally, hence the name *bifidus* of this new species. Like *D. tricuspis* (Fedtschenko 1883), it has a relatively short trident, a much longer female than male, the shorter spicule two-curved, and an oesophagus which enlarges posteriorly. It differs from *D. tricuspis* in the total length of the male and female, measurements of the spicules, finely striated cuticle, and the cleft member of the trident. (See Pl. IX, figs. 18, 19.)

Male. 34–36 mm. in length by 0·49 to 0·51 mm. in breadth. Body tapers at the extremities. Cuticle very finely striated. Head 0·18 mm. wide at the level of the trident bases. Oesophagus expands suddenly 0·2 mm. from the anterior end and becomes twice the width. Male cloaca 0·074 mm. from the posterior extremity. Tail expands laterally, and measures 0·357 mm. in width. Two pairs of pre-anal ventral papillae, six pairs of post-anal papillae, some of the latter probably of the nature of cuticular bosses, and five pairs of lateral papillae of which three are pre-anal and two post-anal. Long spicule 1·21 mm. in length; short spicule, twisted into a loose spiral of two turns, 0·64 mm. in length.

Female. 80–123 mm. in length and 0·55 mm. in breadth at the vulvular region. Oesophageal tridents 0·071–0·085–0·107 mm. long. Their apices may or may not project from the head extremity. Apices are truncated in dorsal or ventral view, rounded in lateral view. Longest member of each trident is cleft distally. The anterior oesophagus is 0·057 mm. in width, and enlarges 0·2 mm.

[1] Retiring Presidential address of Prof. C. W. Stiles of Amer. Soc. of Parasitologists (Section N of the Amer. Assoc. for the Advancement of Science), 1925.

from the head end to 0·114 mm. in width. The vulva is variable in position, being 0·572–0·715 mm. from the anterior end, and slightly salient. The female tail is attenuated and rounded; the anus is subterminal. Eggs, $37\mu \times 51\mu$, contain an embryo.

The measurements, etc., of *D. bifidus* and *D. tricuspis* (Fedtschenko 1883) are given in Table VI.

Table VI.

	D. tricuspis (Fedtschenko 1883)	*D. bifidus* sp. nov.
Length of ♀ body	160–190 mm.	80–91–97–123 mm.
Character of the cuticle	Without transverse rings, occasionally showing inconspicuous cuticular bosses	Fine transverse striations
Structure of oesophagus	Expands suddenly 0·2–0·3 mm. from oral extremity to form posterior region 3 times as wide as anterior region	Expands 0·2 mm. from oral extremity to twice the size of the anterior
Position of vulva in ♀	Variable—from 0·55–0·8 mm. from anterior extremity	Variable—0·572–0·715 mm. from anterior end. Slightly salient
Measurement of the two unequal ♂ spicules	1·4–1·5 mm. and 0·8–0·9 mm.	1·21 mm. and 0·64 mm.
Number and arrangement of the ♂ caudal papillae	Four pre-anal. Two post-anal pairs and three to five more laterally situated pairs	Two pairs pre-anal. Six pairs post-anal. Five more laterally situated pairs
Length of tridents	0·12–0·15 mm.	0·071 mm. 0·085 mm. 0·107 mm. } av. 0·08 mm.

Type No. 5401. Type deposited in the Zoological Laboratory, University of Pennsylvania. Paratypes in Philadelphia Zoological Garden. Hosts:

P.Z.G. No.

5401. *Cyanocorax cyanopagon* (blue-bearded jay). Quoting the protocol: "Coiled above the spleen with parts embedded in cerosa of proventricle a cluster of filarial worms"; Brazil; 3 mo.

5569. *C. chrysops* (pileated jay). "Peritoneal cavity filled with clumps of filarial worms," many; Brazil, Uruguay; 1 day.

5873. „ "Filaria in peritoneum," many; Brazil, Uruguay; 7 mo.

Summary.

Emended descriptions of the female of *Ascaridia hermaphrodita* (Froelich 1789) and of the male of *Wellcomia evoluta* (Linstow 1899) are given. The female of *A. hermaphrodita* is described in full as a description of it does not appear in the literature. Several corrections are made of errors found in descriptions. Especially noticeable is the illustration of the male tail of *W. evoluta* by Yorke and Maplestone (1926, p. 197, fig. 131 E) which they wrongly label "Posterior extremity of female (After Hall)."

Further evidence is furnished upon the probable life-cycle of a species of the genus Eustrongylides in showing that pre-adult stages of *E. wenrichi* Canavan 1929 have been found encysted in a fish, as well as in a frog and

amphiuma ("Congo eel"); the adults of the worm were found in a Canadian goose. Thus confirming Jaegerskiöld in his opinion that fish are the intermediate host and fish-eating aquatic birds are the final hosts of the genus.

Superparasitism is shown to be of fairly common occurrence. Numerous records of new hosts are mentioned. Three worms that previously were found and described by the writer as new were found again. In each case they were encountered in new but closely related hosts to those in which they were previously found.

There are five new species and one new genus described and illustrated in this paper (II): *Pharyngostrongylus brevis* sp. nov. from a Bernard's kangaroo, *Phascolostrongylus turleyi* gen. et sp. nov. from a common wombat. *Oesophagostomum vigintimembrum* sp. nov. from an Arabian camel, *Ascaris hippopotami* sp. nov. from a hippopotamus and *Diplotriaena bifidus* sp. nov. from both blue-bearded and pileated jays.

Finally, there are 209 determinations of 39 genera and 69 species, including new ones, from 181 hosts involving 94 different host species.

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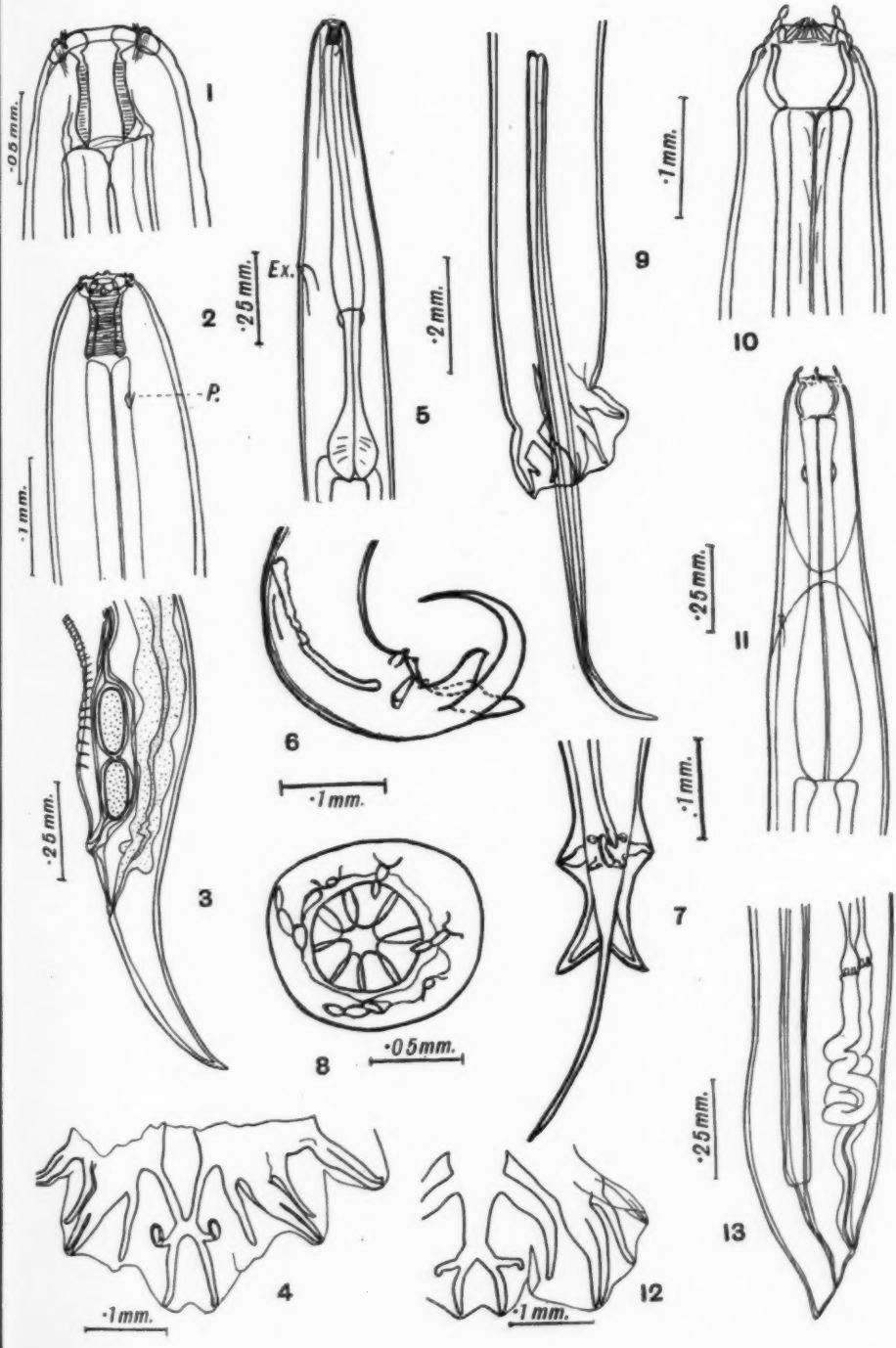
EXPLANATION OF PLATES VIII AND IX.

(All drawings were made with the aid of a camera lucida.)

PLATE VIII.

Fig. 1. *Pharyngostrongylus brevis* sp. nov. Head end; optical section.
Fig. 2. „ „ Anterior extremity; lateral view; *P.* cervical papillae.
Fig. 3. „ „ Tail of female; lateral view.
Fig. 4. „ „ Male bursa; dorsal view.
Fig. 5. „ „ Head end of female showing tapering and oesophagus; *Ex.* = excretory pore; lateral view.
Fig. 6. *Wellcomia evoluta* (Linstow, 1899). Male tail; lateral view.
Fig. 7. „ „ Male tail; ventral view.
Fig. 8. *Phascolostrongylus turleyi* sp. nov. Head end view, showing leaf-crown elements and head papillae.
Fig. 9. „ „ Tail of the male; lateral view.
Fig. 10. „ „ Head end; optical section; lateral view.
Fig. 11. „ „ Head end showing oesophagus; semi-lateral view.
Fig. 12. „ „ Bursa of the male; showing dorsal ray and externo-dorsal arising from a common trunk; dorsal view.
Fig. 13. „ „ Tail of the female; lateral view.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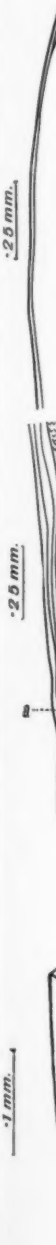
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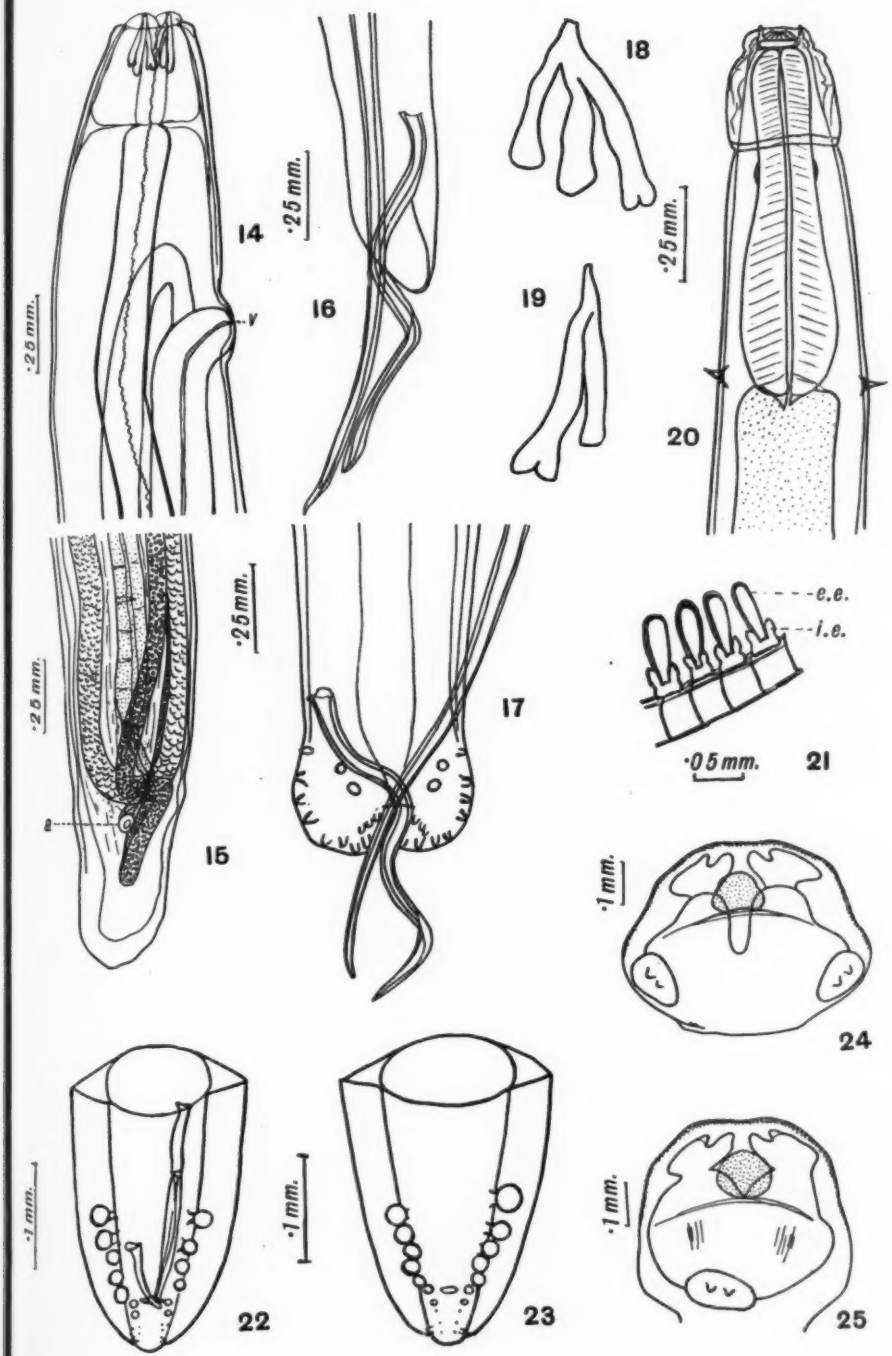
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PLATE IX.

Fig. 14. *Diplotriaena bifidus* sp. nov. Head end of the female; *v.* vulva; lateral view.
Fig. 15. „ „ Tail of the female; *a.* anus; ventral view.
Fig. 16. „ „ Tail of the male; lateral view.
Fig. 17. „ „ Tail of the male; longer spicule dissected; ventral view.
Fig. 18. „ „ A single chitinous trident; lateral view.
Fig. 19. „ „ A single chitinous trident; ventral view.
Fig. 20. *Oesophagostomum vigintimembrum* sp. nov. Anterior extremity of male, showing cervical papillae; ventral view.
Fig. 21. „ „ Portion of dissected oral leaf-crown; *e.e.* external elements; *i.e.* internal elements; internal view.
Fig. 22. *Dirofilaria repens* R. & H. 1911. Tail of the male; ventral view.
Fig. 23. *Dirofilaria subcutanea* (Linstow 1899). Tail of the male; ventral view.
Fig. 24. *Ascaris hippopotami* sp. nov. Dorsal lip, showing lip-pulp; dorsal view.
Fig. 25. „ „ Subventral lip, showing lip-pulp; dorsal view.

(*MS. received for publication* 28. xi. 1930.—Ed.)

NUTTALLIELLA NAMAQUA, A NEW GENUS AND SPECIES OF TICK.

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(With Plate X and 1 Text-figure.)

The following description is based upon a single fully engorged female collected under a stone at Kamieskroon, Little Namaqualand, by Dr R. F. Lawrence in October 1930. Dr Lawrence informs me that rock-rabbits were probably the commonest animals about the hill where he found it, but the host of the tick may be a bird.

This tick is particularly interesting as it appears to be the missing link in the evolutionary chain between the families Argasidae and Ixodidae, and seems to indicate that the Ixodidae may have originated in Africa.

It resembles the Argasidae in possessing a leathery integument; a scutum is present as in the Ixodidae, but instead of being highly chitinous as in that family, it more closely resembles the rest of the integument of the body. The capitulum is situated on the anterior margin as in the Ixodidae, not ventrally as in adult Argasidae. The joints of the palpi are very flexible as in the Argasidae, not ridged as in the Ixodidae; the fourth segment is terminal as in the Argasidae, whereas in the Ixodidae it is situated ventrally at the distal end of the third segment; the second segment is grooved on its inner side, but the two apical segments are not grooved. This, however, is only to be expected as the hypostome is very short. The Argasidae possess ungrooved palpi, whereas in the Ixodidae the second and third segments are grooved on their inner margins, except in the male of *Ixodes putus* (Pickard-Cambridge), a species parasitic upon birds. However, in this species the hypostome is also very short in the male; whether the palpi are grooved or not depends upon the length of the hypostome.

In the Ixodidae the spiracles are generally large and situated well behind coxae 4, whereas in the Argasidae they are very small and situated more anteriorly. Unfortunately in the specimen under discussion these organs could not be located, although they should be present.

It would be very interesting to know the habits of this tick, as the Argasidae differ markedly from those of the Ixodidae in their biology.

It may be pointed out, however, that the teeth of the hypostome are extremely rudimentary, this being an exception in the females of the Ixodidae,

indicating that the tick may be a temporary feeder like species of Argasidae, and does not remain attached to its host for several days as do the species of Ixodidae. On the other hand, it may be noted that the adults of *Ornithodorus megnini* have short rounded unarmed hypostomes and peculiar chelicerae, and there is no evidence that they feed except in the immature stages[1].

As its dominant characters are those of the family Ixodidae, it must be placed in that family. Moreover, it is more closely allied to the genus *Ixodes* than to any of the other existing genera.

Genus NUTTALLIELLA n.gen.

Female characters. *Integument of body* leathery, having a definite pattern (see Pl. X, figs. 1, 2) and resembling that of Argasidae, more especially certain *Ornithodorus* spp. *Scutum* somewhat resembling the rest of the body-integument, especially parts thereof. *Eyes* absent. *Capitulum* situated on anterior margin; porose areas absent. *Hypostome* very short. *Chelicerae* present. *Palpi* short, the joints very flexible; basal segment very small; the second much the largest and grooved on inner surface; the third and fourth cylindrical, the latter being terminal. *Anal groove* curving in front of anus. *Genital* and dorsal grooves absent. *Festoons* absent. *Legs* with most of the joints incised apically on the ventral side; coxae 1 and 2 situated close together, coxae 2, 3 and 4 widely separated; tarsi without spurs. *Haller's organ* present on tarsus 1 as in all Ixodoidea.

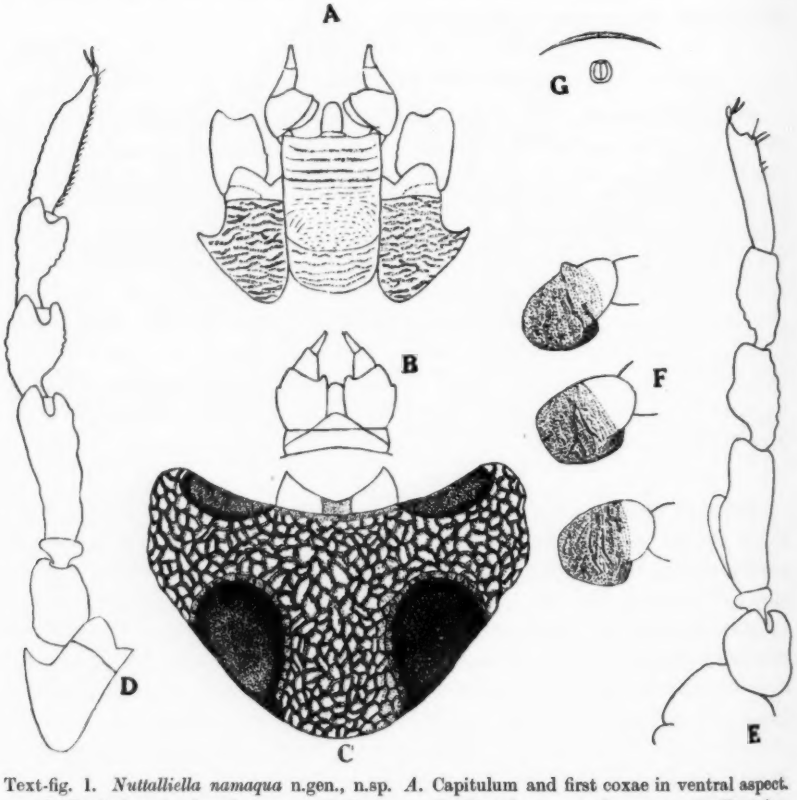
Nuttalliella namaqua n.sp.

Engorged female. *Body* slate-coloured, slightly wider behind than in front 4 × 3·5 mm.; integument pitted (Pl. X, fig. 2), the pits being very shallow and more or less equidistant apart. *Scutum* (Text-fig. 1, *C*) considerably wider than long (0·57 × 1·07 mm.), with two large very deep depressions behind, one on each side on the posterior margin, and two smaller ones on the anterior margin; these depressions are dark and closely resemble the rest of the integument of the body, so much so that it is difficult to see the dividing line between them; the rest of the scutum is pale in colour and honeycombed with deep-irregular pits. It is situated well forward on the anterior margin, lies almost at right angles to the capitulum, and can therefore hardly be seen when the tick is viewed from above. In an unengorged specimen it probably lies in the same or almost the same plane as the capitulum. *Capitulum* (Text-fig. 1, *A* and *B*) orange-coloured with base very short dorsally, elongated ventrally (0·42 × 0·27 mm.), having the lateral margins parallel, the anterior margin straight and the posterior margin slightly convex. *Hypostome* with one or two very rudimentary teeth. *Legs* orange-coloured, pale at the apices of the joints, except coxae 2–4 which are dark basally and pale apically, coxa 1 with a large spur on its outer margin; coxa 2 with a small spur on its anterior margin; coxae 3 and 4 unarmed, the remainder of the joints of legs 2 to 4 very similar

[1] See Nuttall and Warburton (1908), *Ticks, A Monograph of the Ixodoidea*, pp. 72, 73, 104.

to those of the forelegs, which are shown in Text-fig. 1, *D* and *E*. *Genital opening* situated between coxae 2. *Anus* clothed with numerous minute setae, and situated a short distance in front of the posterior margin. *Anal groove* (Text-fig. 1, *G*) rudimentary, pre-anal, and does not continue backwards towards the posterior margin.

The type will be deposited in the South African Museum, Capetown.



Text-fig. 1. *Nuttalliella namaqua* n.gen., n.sp. *A*. Capitulum and first coxae in ventral aspect. *B*. Capitulum in dorsal aspect. *C*. Scutum. *D*. First leg, ventral aspect. *E*. First leg, lateral aspect. *F*. Coxae 2–4, drawn separately. *G*. Anus with crescentic pre-anal groove. (G. A. H. B. del.)

EXPLANATION OF PLATE X.

Nuttalliella namaqua n.gen., n.sp.

Fig. 1. Engorged female in dorsal aspect. Size 4 × 3·5 mm.
Fig. 2. Portion of body-integument more highly magnified.

(*MS. received for publication* 16. XII. 1930.—Ed.)

Fig. 1

Fig. 2

THE APPENDAGES OF *BASANISTES HUCHONIS* (SCHRANK) (COPEPODA).

By W. HAROLD LEIGH-SHARPE, M.Sc. (Lond.).

(With 4 Text-figures.)

Record and Habitat. I am indebted to Dr Theodore Monod of Paris for his kindness in sending me four female specimens of *Basanistes huchonis* (Schrank) which, according to him, is common on *Salmo hucho* on the inner side of the operculum, in the rivers of Continental Europe. In 1928, *Parasitology*, **20**, 183, I gave an account (in which by an error the specific names of the host and parasite were unfortunately interchanged) of the external features, with figure, from the single specimen in the British Museum, which it is unnecessary to repeat here. As the Museum specimen lacks a bulla and the appendages of *Basanistes*, owing to its apparent rarity, have not been adequately described, I append the following account. The male is still unknown.

The **appendages** of the head are remarkable for their extremely small size (Fig. 1); the bulla, on the other hand, is enormous (Fig. 2).

First antennae (Fig. 1, *A* 1) two-articled, the basal article very stout and longer than the terminal, which is tipped by three spiniferous processes.

Second antennae (Fig. 1, *A* 2) not much larger than the first pair, stout, biramous, the endopodite spherical and capped with three spiniferous processes, the exopodite ending in a curved, serrated claw.

Upper and lower lips well defined, the former with a median projection.

Mandibles (Fig. 1, *Mn.*, Fig. 4) slender with six teeth of about equal size, and end in a spiked projection.

First maxillae, similar to those usual in the Lernaeopodidae, but there does not appear to be an exopodite. The unsegmented endopodite is tripartite at the distal end, one ramus being terminal and the other two on the inner margin. Each ramus ends in a mammillated spine.

Second maxillae (Fig. 2) of medium length, stout, wrinkled, enlarged proximally and inserted at the sides of the head, free as far as their distal ends, which are expanded into discs with thick borders. *Bulla* extremely large, clavate, narrow, with a long manubrium having a calyx-like base, and containing two channellings in the manner of *Clavella*.

Maxillipedes (Fig. 1, *Mp.*) stout, standing well out in front of the second maxillae. Basal article much longer than wide. Terminal article fairly stout, ending in a curved claw without accessory spines. This claw shuts down upon a doubly-mammillated boss on the basal article, suggestive of *L. mustelicola*

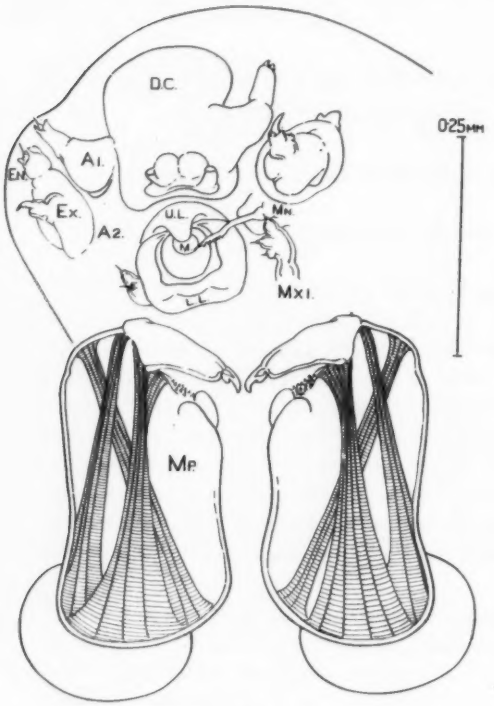


Fig. 1.

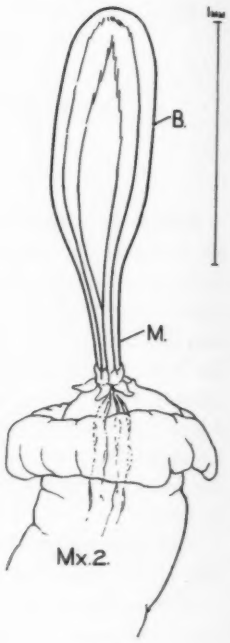


Fig. 2.

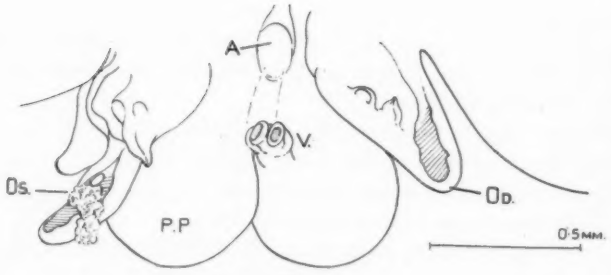


Fig. 3.

Fig. 4.

(*Parasitology*, **11**, 262, Fig. 4 D), above which is a pad of spines difficult to observe.

The posterior end of the trunk terminates in two rounded knobs which are the homologues of the posterior processes. Anterior to these, displaced in Fig. 3, are the prominent vulvae, standing out on a well-marked process. The egg-strings emerge each in a groove along a trowel-shaped projection, along which their proximal portion lies (Fig. 3, *Od.*), and into which the oviducts open.

There is a minute dorsal carapace (Fig. 1, *D.C.*).

Between the bases of the first antennae is a paired problematical structure (Fig. 1) which appears to possess apertures.

LEGENDS TO TEXT-FIGURES.

Fig. 1. *Basanistes huchonis* ♀, anterior end, flattened, much magnified, from a balsam-mounted slide. *D.C.* = dorsal carapace; *A.* 1 = first antenna; *A.* 2 = second antenna; *Ex.* = exopodite; *En.* = endopodite; *U.L.* = upper lip; *M.* = mouth; *L.L.* = lower lip; *Mn.* = mandible; *Mx.* 1 = first maxilla; *Mp.* = maxillipede.

Fig. 2. *Basanistes huchonis* ♀. *Mx.* 2 = expanded end of a second maxilla, with disc; *B.* = bulla; *M.* = manubrium.

Fig. 3. *Basanistes huchonis* ♀. The posterior end of the trunk flattened out. *P.P.* = posterior processes; *V.* = vulvae; *Os.* = remains of the cement substance of an egg-string; *Od.* = expanded trowel-like process of the body into which the oviduct opens and from which the egg-strings emerge; *A.* = Anus.

Fig. 4. *Basanistes huchonis* ♀. Mandible.

(*MS. received for publication* 30. XII. 1930.—Ed.)

DESCRIPTIONS OF THREE NEW SPECIES OF *TETROPHTHALMUS* (MALLOPHAGA) FOUND ON PELICANS.

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(With 6 Text-figures.)

The genus *Tetrophthalmus* includes seven species found on pelicans, and to these we are now adding three more as follows:

(i) *Tetrophthalmus subtitan* n.sp. taken off *Metapelecanus roseus* Gmel. (eastern white pelican) at the junction of the Olifant and Limpopo Rivers, Mozambique, on August 1st, 1915.

(ii) *Tetrophthalmus africanus* n.sp. found on *Neopelecanus rufescens* Gmel. (pink-backed pelican) in the Zoological Gardens, Pretoria, on September 16th, 1914.

(iii) *Tetrophthalmus australis* n.sp. recorded taken off a pelican on Lake Courel, New South Wales. There is only one species of pelican known to occur in Australia, namely, *Catoptropelecanus conspicilatus* Temm. and Laug., and this bird has been recorded from several localities in New South Wales.

In all the known species of *Tetrophthalmus* the shape of the head, thorax and abdomen appears to be similar; also the chaetotaxy, with the exception of the setae on the abdomen, and as Ferris (1928: *Parasitology*, **20**, 224, fig. 8 *A–J*) has recently described and given excellent figures of *T. chilensis* Grosse, a species found on *Pelecanus thagus* in Peru, it will only be necessary in this paper to refer to the differences we have noted in the above species, and also in *T. titan* (Piaget). For the loan of a female and male of *T. titan* taken off the type host, *Pelecanus onocrotalus* L., by my brother, Mr H. W. Bedford, at Khartoum, Sudan, the writer is deeply indebted to Mr R. B. Benson of the British Museum (Natural History).

In the genus *Tetrophthalmus* the males may be either slightly larger or smaller than the females. Other differences we have noted between the sexes of the above new species, and also of *T. titan*, are, the males are slightly darker, the tergal plates are slightly more developed, and the pale area at the bases of the mid and hind femora is smaller in the males than in the females. The males also differ from the females in having the apex of the abdomen more pointed, possessing a spur at the apex of each tibia, and the mid and hind femora are somewhat more robust. Piaget's figure (*Les Pédiculines*, 1880, Pl. 40, fig. 7) of *T. titan* is much too dark. The thorax and abdomen of this and the three new species are pale with brown to dark brown markings and plates.

Specific characters.

The chief differences we have noted in the species referred to above are: (i) the shape of the plate on the gular region of the head, (ii) the shape of the plates on the meso- and metasternum, (iii) the transverse plates on the tergites, (iv) the plates and markings on the seventh and eighth sternites of the female and on the eighth and ninth sternites of the male, and (v) the male genitalia.

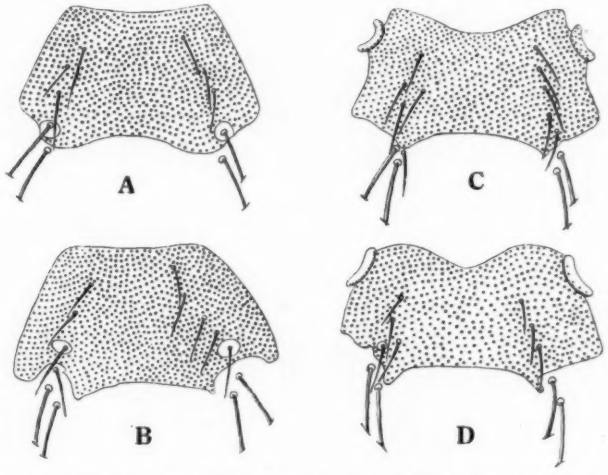

Fig. 1. Gular plates of: A, *Tetrophthalmus titan* (Piaget); B, *T. subtitan* n.sp.; C, *T. africanus* n.sp.; D. *T. australis* n.sp.

(i) *The gular plate.* The plate and setae on the gular region are usually slightly asymmetrical and therefore, as is only to be expected, vary slightly in different individuals of the same species. On comparing Fig. 1 A–D it will be observed that the gular plates of *titan* (1 A) and *subtitan* (1 B) are very distinct from those of either *africanus* (1 C) or *australis* (1 D). In both *titan* and *subtitan* the apical pair of setae on the plates are situated in large pustules, these pustules being entirely absent on the gular plates of *africanus* and *australis*, except in one female of the latter the apical seta on the left arises from a small pustule. Moreover, in both sexes of *africanus* and *australis* there are two small ear-shaped plates attached to the gular plate, one on each side on its latero-anterior margins, these being entirely absent in both *titan* and *subtitan*.

(ii) *The plates on the meso- and metasternum.* These plates are also asymmetrical and vary slightly in different individuals of the same species (Fig. 2 A–D). The shape of the median plates on the metasternum of *titan* (Fig. 2, A 2, 3) and *subtitan* (Fig. 2, B 2, 3) is also quite distinct from that in *africanus* (Fig. 2, C 2, 3) and *australis* (Fig. 2, D 2, 3), and the females of the latter

possess a pair of small admedian plates beneath the median plate; these being present also in the females of *chilensis*. They are absent in the females of *titan* and *subtitan*, and in the males of all these species, except possibly *chilensis*.

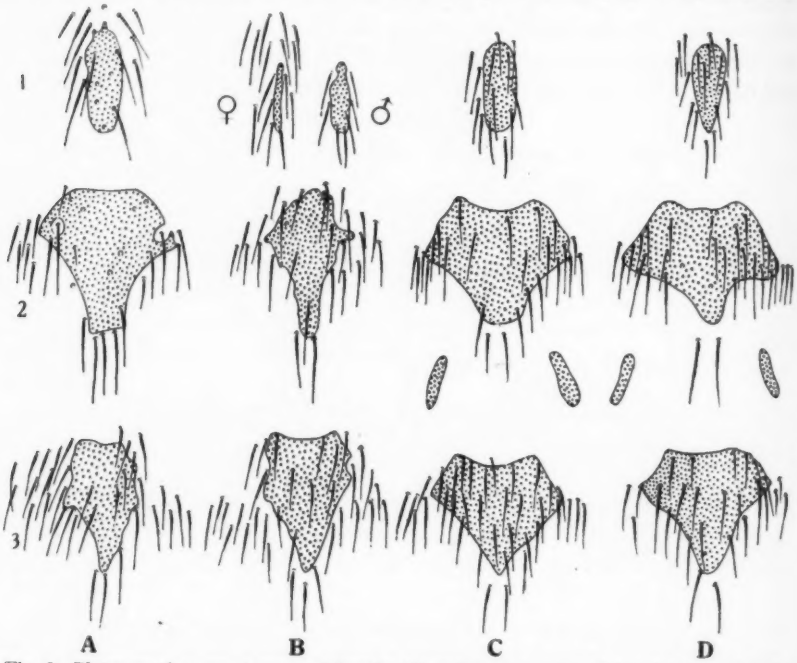

Fig. 2. Plates on the mesosternum of females (1) and metasternum of females (2) and males (3) of: A, *Tetrophthalmus titan* (Piaget); B, *T. subtitan* n.sp.; C, *T. africanus* n.sp.; D, *T. australis* n.sp.

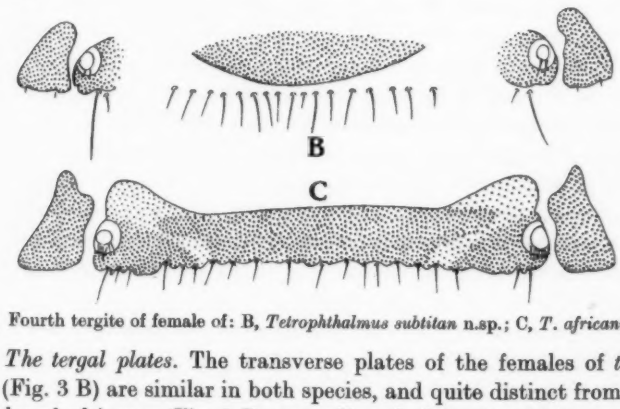

Fig. 3. Fourth tergite of female of: B, *Tetrophthalmus subtitan* n.sp.; C, *T. africanus* n.sp.

(iii) *The tergal plates*. The transverse plates of the females of *titan* and *subtitan* (Fig. 3 B) are similar in both species, and quite distinct from those of the females of *africanus* (Fig. 3 C), *australis* and *chilensis*, which are also very similar. In the females of *titan* and *subtitan* they are interrupted on each side

of the middle, whereas in *africanus* and *australis* they are complete, and the hairs on the posterior margins are shorter and arise from incomplete pustules. In the males of these species the tergal plates are similar and resemble those of the females of *africanus* and *australis*, except that a number of the pustules are complete. In all four species the transverse plate on tergite 1 is absent in the females, and only visible on the sides, close to the pleurites, in the males. In *chilensis* the plate on tergite 1 is well developed. In the females of *titan* and *subtitan* the plate on tergite 2 is rudimentary and only visible at the sides.

(iv) *Setae on spiracles.* The spiracles, which are present on tergites 3 to 8, possess small setae on their posterior margins. The number of setae on the spiracles not only varies in the different species, but also on the left and right spiracles of the same individual. The numbers given in the following table refer to the setae on the left and right spiracles of different individual specimens.

Table showing number of setae on spiracles.

	T. titan		*T. subtitan*		*T. africanus*		*T. australis*	
Tergite	Female	Male	Female	Male	Female	Male	Female	Male
3	2·2	2·2	2·2	2·2	6·6	4·4	4·4	6·6
4	3·3	3·5	2·2	3·2	6·7	4·4	5·6	5·9
5	3·3	2·3	3·2	3·3	6·6	7·4	5·5	6·5
6	4·2	4·3	3·3	3·3	6·5	6·6	4·6	3·5
7	3·3	4·4	3·3	2·2	4·2	3·3	4·5	5·5
8	1·2	2·2	1·1	1·1	4·3	4·3	4·6	3·3
Total	14–17	16–20	13–14	13–14	28–33	24–28	26–32	27–34

It will be seen from the above table that the setae are less numerous in *titan* and *subtitan* than they are in either *africanus* or *australis*. In *chilensis* there are, according to Ferris' figure of the female, about seventeen setae on the spiracles. These setae are not, however, of any specific importance, as we have seen a female and male of *africanus* taken off a pelican in the Belgian Congo in which the total number of setae present on the spiracles on each side was about fourteen.

(v) *Pleurites.* In *titan*, *subtitan*, *africanus* and *australis* the pleurites have two or three minute setae on their posterior margins, except those on the first two segments which have longer setae, whereas in *chilensis* the setae are considerably longer, being about the same length as those on the posterior margins of the tergites.

(vi) *Plates on the apical sternites of female and male.* On comparing Fig. 4 A–D it will be seen that the plates on sternites 7 and 8 of the females differ in shape in the different species, and that those of *titan* and *subtitan* are very distinct from those of *africanus* and *australis*. Likewise, the plates on sternites 8 and 9 of the males of *titan* (Fig. 5 A) and *subtitan* (5 B) are of one type, and those of *africanus* (5 C) and *australis* (5 D) are of another type. In *subtitan* the posterior plates are absent, in *titan* they are extremely narrow, and in

africanus and *australis* they are considerably longer and broader. In the males of all these species there are a number of setae on the margin of the ninth sternite.

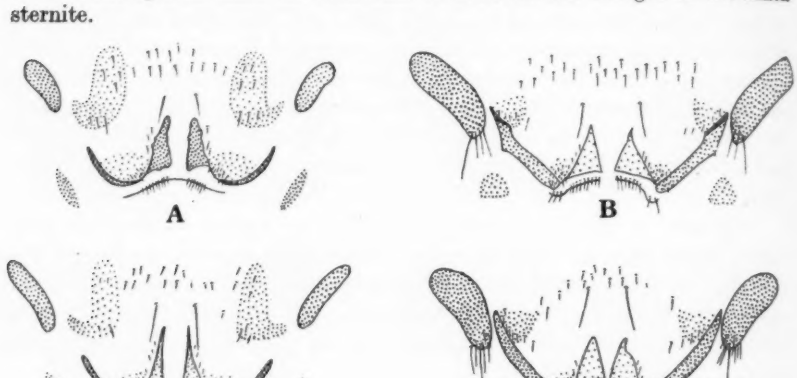

Fig. 4. Plates on sternites 7 and 8 of females of: A, *Tetrophthalmus titan* (Piaget); B, *T. subtitan* n.sp.; C, *T. africanus* n.sp.; D, *T. australis* n.sp.

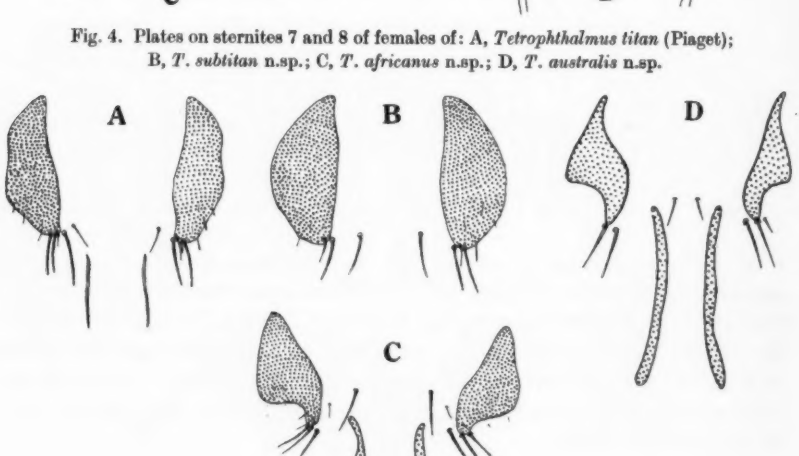

Fig. 5. Plates on apical sternites of males of: A, *Tetrophthalmus titan* (Piaget); B, *T. subtitan* n.sp.; C, *T. africanus* n.sp.; D, *T. australis* n.sp.

(vii) *Male genitalia.* Unfortunately we have not been able to dissect out the genitalia of all the species reported upon in this paper, therefore complete descriptions and drawings cannot be included. However, it would appear that they are distinct in all species, and that those of *titan* and *subtitan* belong to one group and those of *africanus* and *australis* to another group, the former

being more developed than the latter. The basal plate is very long and narrow in all species; in Fig. 6 A only the apex of the plate is shown, likewise only the

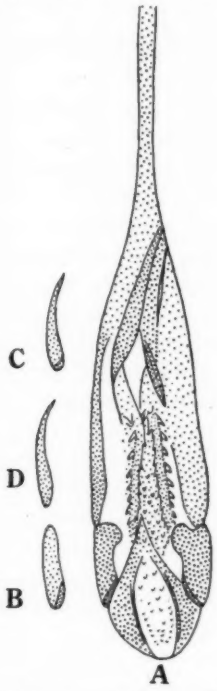

Fig. 6. A, genitalia of male of *Tetrophthalmus titan* (Piaget) (bases of basal plate and preputial sac not shown); B, parameres of *T. subtitan* n.sp.; C, parameres of *T. africanus* n.sp.; D, parameres of *T. australis* n.sp.

apex of the preputial sac. The parameres of *titan* (6 A) are wider at their bases than those of *subtitan* (6 B), those of *africanus* (6 C) and *australis* (6 D) being very similar to one another and longer and narrower than those of the former.

Measurements in mm.

	T. titan				*T. subtitan*			
	Female		Male		Female		Male	
	Length	Width	Length	Width	Length	Width	Length	Width
Head	0·62	1·12	0·62	1·21	0·57	1·17	0·69	1·12
Prothorax	0·46	0·87	0·46	0·96	0·50	0·91	0·53	0·89
Pterothorax	0·64	1·14	0·53	1·23	0·55	1·12	0·53	1·21
Abdomen	4·10	1·81	3·91	1·71	3·86	2·01	3·86	1·71
Total	5·82		5·52		5·48		5·61	
	T. africanus				*T. australis*			
Head	0·69	1·14	0·67	1·23	0·71	1·12	0·57	1·12
Prothorax	0·46	0·94	0·57	1·01	0·48	0·94	0·53	0·96
Pterothorax	0·57	1·19	0·46	1·39	0·55	1·21	0·57	1·32
Abdomen	3·89	1·92	2·88	1·52	3·82	1·97	3·60	1·69
Total	5·61		4·58		5·56		5·27	

Piaget, in his description of *T. titan*, states that the male is larger than the female.

Holotypes of the new species: the females.

SUMMARY.

On comparing the figures it will be observed that all the specific characters of *Tetrophthalmus titan* (A in all figures) closely resemble those of *T. subtitan* (B in all figures), and that these two species constitute one group; also that the specific characters of *T. africanus* (C in all figures) closely resemble those of *T. australis* (D in all figures), and that these species belong to another group, which must also include *T. chilensis*.

Judged by their parasites, the Ethiopian pelican, *Neopelecanus rufescens*, is more closely allied to both the Australian pelican, *Catoptropelecanus conspicilatus*, and the South American species, *Pelecanus thagus*, than it is to either *Pelecanus onocrotalus* or *Metapelecanus roseus*, both of which also occur in the Ethiopian region. Moreover, if the parasites throw any light on the phylogeny of their hosts, *thagus* cannot remain in the genus *Pelecanus* along with *onocrotalus* if the genera *Neopelecanus*, *Metapelecanus* and *Catoptropelecanus* are to remain valid.

(*MS. received for publication* 5. XI. 1930.—Ed.)

NOTES ON BREEDING FLEAS, WITH REFERENCE TO HUMIDITY AND FEEDING.

By ENID K. SIKES, Ph.D., B.Sc.

Department of Entomology, London School of Hygiene and Tropical Medicine.

(With a Chart.)

While carrying out experiments on the feeding of flea larvae, it became evident that the humidity of the air in the breeding vessel was important, but that the optimum atmospheric humidity varied according to the kind of food provided. Accordingly, experiments were carried out to investigate the hygroscopic properties of certain food substances, based on the experiments done by Buxton (1924) on fragments of vegetation in deserts. Dried blood, blood albumen (prepared by evaporation not by precipitation) and fine particles from the bottom of a squirrel's nest, were used as examples. The nest material was not altogether a satisfactory example of food, as it was a mixture whose constitutents varied according to the part of the nest from which it was taken. The sample used in these experiments contained a large percentage of adult flea faeces.

Each substance was ground up, weighed and then dried over a water bath at 100° C. until the weight was constant. The dried blood lost 24·4 per cent. of its original weight, the albumen lost 19·6 per cent. and the nest material 8·5 per cent. The substance was then spread in a thin layer in a Petri dish. Less than a gram of dry substance was used in each experiment. The substances were then exposed to atmospheres of 10, 20, 30, etc., to 100 per cent. relative humidities. The dried blood and nest material were weighed after 24 hours in each atmosphere and the albumen after 48 hours in each as it took longer to reach a constant weight. The Petri dishes were placed in desiccators over a mixture of sulphuric acid and water in the proportion to give the required humidity. 150 c.c. of the acid were put in the bottom of each desiccator. The temperature of the laboratory cupboard in which the experiments were conducted varied between 15° and 21° C. The experiment with albumen was carried out in a constant-temperature room at 21° C.

The dried blood (see B in Chart) took up moisture slowly and steadily through all the different humidities, and continued to do so for seven days in 100 per cent. relative humidity. Assuming that the weight of dry blood before the experiment was 100 units, the weight was finally 164·1, of which 64·1 was water absorbed from the atmosphere. With albumen (see C in Chart),

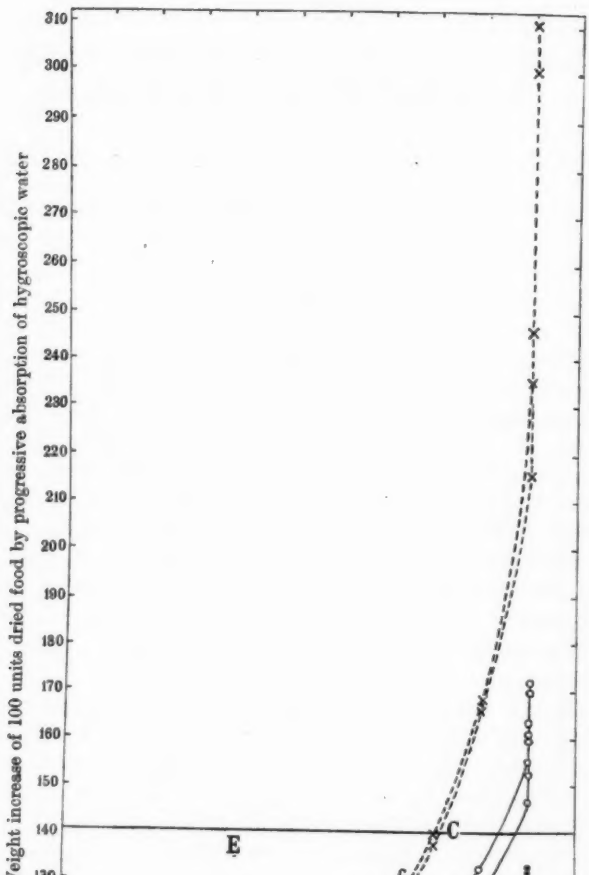

Chart: Hygroscopic absorption curves for A, A, squirrel's nest material, B, B, dried blood, C, C, blood albumen. A, B, C, material dried before exposing to given humidities. A, B, C, material dried after exposing to given humidities. Ordinate shows increase in weight due to water absorbed by 100 units of dry material. Abscissa shows relative humidity of atmosphere. The curves lying between lines DE show the region in which the larvae will breed.

100 units of dry material finally became 301·8 of which 201·8 was water; it gained weight for 4 days in 100 per cent. relative humidity. The nest material (see A in Chart) gained weight very gradually, and starting with 100 units of dry substance, the final weight was 133.

It seems probable that drying the substances at 100° C. to constant weight before the experiment might have altered their composition and interfered with their hygroscopic property, so a second experiment was carried out wherein the substance was dried to constant weight after it had been weighed over a full range of humidities (see A, B, C in Chart). The results were found to agree with the first in all essentials; the difference is recorded in the Chart.

FEEDING FLEA LARVAE IN THE LABORATORY.

Ever since the days of Leeuwenhoek (1683), scientists have been experimenting on methods of breeding flea larvae in the laboratory. The food used by these early naturalists for the larvae has been briefly mentioned elsewhere (Sikes, 1930).

Bacot (1914) showed that many species of flea larvae require blood in their food and will not grow without it. In nature this is provided by the adult fleas, which swallow more blood than they can digest, so that some of it passes out with the faeces as scarcely digested blood. In the laboratory, it is convenient to be able to breed the larvae apart from the adults on a simple food of known constitution, and on which their growth can be watched easily with variation of temperature and humidity as required.

Various methods of feeding and types of food have been tried, using the flea, *Ceratophyllus wickhami*, from the nest of the North American grey squirrel (*Sciurus carolinensis*). The larvae were kept in small specimen tubes, about 2 in. × 1 in., and these were smeared round the top with vaseline to prevent any larvae from escaping if they succeeded in climbing the sides. Other vessels were tried, such as Petri dishes and plaster boxes, but the small specimen tubes proved to be the most convenient, as a large number could be kept in one desiccator. Also they were deep enough to keep the larvae from climbing out and shallow enough to allow me to examine the larvae with a binocular miscroscope.

When feeding larvae of *Ceratophyllus wickhami* on dried blood, albumen and nest material, it was found that they survived best at 80 to 90 per cent. relative humidity if fed on dried blood, 70 to 80 per cent. r.h. if fed on albumen, and 90 per cent. r.h. or above if fed on the nest material. It appears, then (see Chart), that there is a definite optimal water content for the larvae, which are best suited if 100 parts by weight of food have absorbed between 18 and 40 parts of water (see D, E in Chart), that is 15 to 28 per cent. of water is required in the food. This water content is obtained when the different substances used as food are in equilibrium with air at *different* relative humidities.

It appears that the water content of the food of flea larvae is a very important factor in breeding, and the maximum and minimum quantities probably vary for each species of flea. It is at least possible that atmospheric humidity affects the flea larva indirectly, through its food, and not only directly by regulating the loss of water from its surface.

Different batches of larvae were fed on dried blood, albumen, flea faeces and other substances at various humidities. These were given alone or mixed with sand or other medium as shown in Table I. Other substances used as food besides those shown in the table were dead adult fleas, squirrel faeces, ground-up cockroach, coagulated albumen and egg albumen. The larvae were seen to feed on each of these substances, but never reached the adult stage, though a few lived for 20 days on dead adult fleas, 9 days on squirrel faeces and 18 days on egg albumen, which is longer than they lived without food. Probably the two first-mentioned substances play an important part as larval food in a squirrel's nest when the flea stock is very low and adult flea faeces at a minimum. The larvae died within two or three days when fed on ground-up cockroach. The coagulated blood albumen had the same effect; it probably did not provide them with sufficient water as it is insoluble, though the larvae were seen to eat it.

In many experiments it is desirable to have larvae breeding in a medium where everything is known and controlled. In most cases where food was given alone, the larvae did not thrive and pupated without spinning a cocoon. It was, therefore, necessary to find a substrate which is neither hygroscopic nor nutritive, and which satisfies the mechanical needs of the larvae, that is, something to walk in and to use in cocoon making. Fine sand mixed with the food was the best medium, as it does not absorb moisture or interfere with the experiments in any way. The flea larvae prefer cloth to crawl about upon, but this can only be used for general breeding purposes and not when the humidity is to be controlled. Glass wool was tried as a medium, but the larvae ate it and died. Bran is sometimes used, but as it absorbs moisture it has the same objections as cloth.

The experiments recorded in Table I were carried out at a constant temperature of 21° C. Other similar experiments were done in a cupboard at a temperature of 15–18° C. and in an incubator at 24° C., but the temperature seemed to make little difference to the survival of this species of larva, only affecting the rate of development.

Twenty-five flea larvae were used for each experiment, whenever possible. The larvae were newly hatched, care being taken that they had had no food. As the mother flea always defaecates beside the egg when she lays, it was necessary to remove the eggs from the laying vessel before they hatched, in order to be sure that the larvae were unfed. The newly hatched larvae were fed on the various foods, and only those which reached the adult stage were counted.

The specimen tube with food in it was put into a desiccator containing an

Table I.

Effect of breeding flea larvae on various (hygroscopic) foods at different percentages of relative humidity. (Temperature 21° C.)

	Larvae which reached adult stage	Newly hatched larvae used	Larvae which reached adult stage	Newly hatched larvae used	Larvae which reached adult stage	Newly hatched larvae used	Larvae which reached adult stage	Newly hatched larvae used	Larvae which reached adult stage	Newly hatched larvae used
Rabbit blood	—	—	15	27	9	25	0	—	0	25
Rabbit blood and sand 1	0	25	0	20	17	25	0	25	0	21
" " " 2	—	—	0	25	0	25	—	—	0	25
" " " 3	—	—	7	25	10	25	—	—	0	25
" " " 4	—	—	—	—	6	25	—	—	0	25
Rabbit blood on cloth 1	—	—	0	25	15	25	0	25	0	25
" " " 2	—	—	0	25	3	25	0	25	0	25
" " " 3	—	—	—	—	0	25	—	—	—	—
Rat blood and sand	—	—	9	16	3	25	—	—	0	25
Rat blood on cloth	—	—	1	21	0	25	—	—	0	25
Squirrel blood and sand 1	—	—	8	20	0	25	—	—	0	25
" " " 2	—	—	—	—	0	25	—	—	0	25
Squirrel blood on cloth	—	—	1	25	0	25	—	—	0	23
Human blood and sand	—	—	7	25	11	25	—	—	0	25
Human blood on cloth	—	—	13	25	10	25	—	—	0	25
Flea faeces and sand	2	25	10	25	15	25	—	—	0	25
Flea faeces on cloth 1	—	—	0	25	18	25	—	—	0	25
" " 2	—	—	0	25	3	20	—	—	0	25
Albumen (evaporated)	—	—	0	25	2	25	2	25	1	25
Albumen and sand 1	—	—	0	25	0	25	1	25	2	25
" " 2	—	—	0	25	0	25	0	25	0	25
Albumen on cloth	—	—	3	25	10	25	3	25	0	25
Total	2	50	74	454	132	545	6	175	3	519
	4% at 95% r.h.		16·3% at 90% r.h.		24·2% at 80% r.h.		3% at 75% r.h.		0·6% at 70% r.h.	

atmosphere of known humidity, at least one day before the larvae were added. The food was, therefore, in equilibrium with the atmosphere. Experiments were carried out in relative humidities of 50, 60, 70, 75, 80, 90 and 95 per cent. No larvae survived below 70 per cent. and a very few above 90 per cent. Only 70–95 per cent. are, therefore, recorded in Table I.

In these humidities, of the 1743 newly hatched larvae used, 217 reached maturity. Of these, 132 were reared at 80 per cent. r.h., which appears to be the most favourable for general use and with any food. A 90 per cent. r.h. seems to be moderately successful, as 74 survived. It seems probable that there are factors other than humidity and temperature causing the low percentage of emergence even at the most favourable humidity. Possibly there are impurities in the atmosphere caused by the sulphuric acid mixture, although "pure" sulphuric acid and distilled water were used.

As mentioned above, larvae fed on dried blood require a relative humidity between 80 and 90 per cent., and those on albumen can survive at lower humidities. It seems to make no difference from what animal the blood is taken, in fact these larvae seemed to thrive better on human or rabbit blood than on blood from the grey squirrel, which is the host of *C. wickhami*. In this connection it may be mentioned that the flea, *C. wickhami*, has been successfully bred on a white mouse in the laboratory, in which case the larvae would be having mouse blood in their parents' faeces.

Evaporated blood albumen provides a simple food for flea larvae and on this they can be bred, but only extremely slowly, many dying before the first moult. Larvae can be successfully reared on dried blood, however. This may be taken from a rabbit, man, rat or squirrel, evaporated to dryness and then ground to a powder.

Other species of flea larvae have been reared on dried blood alone, but only at a few humidities. *Xenopsylla astia* and *Ceratophyllus fasciatus* were successfully bred on dried blood with 80 per cent. r.h. in a breeding vessel. Larvae of *Archaeopsylla erinaceus* and *Hystrichopsylla talpae* died before the first moult when fed on dried blood alone, but these were only tried at 60 and 80 per cent. r.h., so that the experiments are incomplete.

Summary.

Experiments were carried out to show the different hygroscopic properties of certain foods supplied to flea larvae. These show that larvae of *Ceratophyllus wickhami* require about 15 to 28 per cent. of water in their food. Dried blood, albumen (blood) and material from the bottom of a squirrel's nest were used.

Newly hatched flea larvae were fed on different substances at varying humidities and a constant temperature. A relative humidity of 80 per cent. gave the best results.

Dried blood is a convenient food for breeding flea larvae in the laboratory, and may be used with or without a mixing medium, such as sand. Albumen is

a more simple food on which a few larvae will survive, but at lower humdities than dried blood.

Flea larvae will eat a great variety of other foods, including squirrel faeces, ground-up cockroach and dead adult fleas, but these do not provide a complete diet.

It does not seem necessary for the larvae to have dried blood from the host of their parents, rabbit or human blood being quite as satisfactory.

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(*MS. received for publication* 31. I. 1931.—Ed.)

ON CESTODES COLLECTED IN BURMA. PART II.

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(With 6 Text-figures.)

Family DAVAINEIDAE Fuhrmann 1907.

Sub-family DAVAINEINAE Braun 1900.

Cotugnia Diamare 1893.

C. (?) browni Smith 1908.

Host: *Palaeornis eupatria* (L.).

Only a few immature fragments found. Rostellar hooks 0·011–0·014.[1] A spiny collar present posterior to rostellum. Attributed to this species by reason of its being the only cestode of the family recorded from this host, and by the agreement in size of the rostellar hooks. As the original description is so inadequate it is unfortunate that the present form is immature.

C. fila n.sp.

(Fig. 1.)

Host: Duck.

Length 55, greatest breadth 3. Scolex absent. Genital pore at anterior third of proglottis margin. Genital cloaca narrow, fairly deep. Cirrus sac long and narrow, in mature segments 0·24–0·26 × 0·025–0·031, in gravid 0·3–0·41 × 0·029, extending to or just past ventral longitudinal excretory vessels. Coils of vas deferens few. Testes 39–45, in a single band, 4–5 deep antero-posteriorly, extending along border of proglottis posterior to female glands and also laterally to excretory vessels, 0·062–0·069 dia. Receptaculum seminis rather small. Ovary crescent-shaped, with external finger-like processes, touching excretory vessel. Vitelline gland bluntly lobed. Eggs singly in capsules, extending laterally to excretory vessels.

The presence of a continuous group of testes, together with a cirrus sac reaching the excretory vessels, separates the present form from all others of the same genus except *C. brotogerys* Meggitt 1925, *C. joyeuxi* Baer 1924, *C. parva* Baer 1925, and *C. seni* Meggitt 1926. The limitation of the testes to the posterior end of the proglottis separates it from *C. brotogerys*. *C. seni* has a cirrus sac 0·19 long, a large receptaculum seminis, and a shallow genital cloaca: *C. parva* has a cirrus sac of the same size, a large receptaculum seminis and testes 0·01 dia: taken in connection with the different families of the hosts these characters sufficiently separate the forms. From *C. joyeuxi*, only known

[1] All measurements in mm.

from immature fragments, there is nothing to distinguish the present form: should the specimens described below agree with the type, the two species are separated by the proportionate and actual sizes of the cirrus sacs.

C. joyeuxi Baer 1924.

Host: *Columba punicea* (Tickell 1842).

Eight strobilae were found in the duodenum. Greatest length 19, greatest breadth 1·2. Scolex 0·67 dia. Rostellum 0·19 dia. Rostellar hooks 0·012–0·014 long. Genital pore slightly anterior to centre of proglottis margin. Cirrus sac 0·075 × 0·044, not reaching ventral excretory vessels. Testes approximately 50, in a continuous band across proglottis in 3–5 rows antero-posteriorly, mostly internal to female organs. Ovary nearly touching excretory vessels. Gravid proglottides absent.

This species has hitherto been recorded only once, from *Stigmatopelia senegalensis*, in French Guinea. The specimens were more immature than the present form, thus accounting for the discrepancies.

C. parva Baer 1925.

Host: *Chalcophaps indica* (L. 1766).

Maximum length 19, maximum breadth 1·1. Scolex 0·5 dia. Rostellar hooks 0·012–0·014 long, mostly so firmly embedded in the intestinal wall and debris that they were torn away from the rostellum. Genital pore at centre of proglottis margin or slightly anterior to it. Cirrus sac 0·16–0·19 × 0·04–0·05, extending to excretory vessels. Testes 35–41, in a single broad continuous band extending across the proglottis and extending anteriorly to the anterior level of the female organs: all internal to the excretory vessels.

The present form differs from the original description (Baer 1925, p. 247) of the form from a crow in the Belgian Congo only in the slightly smaller size of the rostellar hooks and the larger number of testes. In spite of the different systematic position of the hosts, these do not seem sufficient to justify the creation of a new species.

Raillietina Fuhrmann 1920.

R. anatina (Fuhrmann 1909).

Host: Duck.

R. birmanica Meggitt 1926.

Host: Fowl.

In a previous description (Meggitt 1926, p. 227) it was stated that gravid proglottides could not be found. In the present case they were present and contained 1–3 eggs in each capsule.

R. fecunda n.sp.

Host: Duck.

Maximum length 120, maximum breadth 1·2. Scolex 0·2–0·3 dia. Rostellum 0·1–0·15 dia.: rostellar hooks 300, 0·008–0·011 long. Suckers armed with 3–5 rows of hooks, diminishing internally in size. Posteriorly to rostellum a

spiny collar. Genital pore unilateral, slightly anterior to centre of proglottis margin. Cirrus sac 0·05–0·087 × 0·031–0·047, not reaching longitudinal nerve. Vas deferens coiled normally. Testes 25–40, lateral to female glands. Ovary little lobed. Eggs singly in capsules, extending externally to excretory vessels.

Excluding the following species, of which no description is here available, *R. circumcincta* (Krabbe 1869), *R. conopophilae* (Johnston 1912), *R. globocephala* (Fuhrmann 1908), *R. osipowi* Skrjabin and Popoff 1923 and *R. sphaerocephala* (Rudolphi 1819), none of which is from Anseriformes, the only species with unilateral genital pores, eggs singly in capsules extending laterally to the excretory vessels, a cirrus sac not reaching the excretory vessels, and rostellar hooks approximately 0·01 long are *R. clavulus* (Linstow 1888) and *R. reynoldsae* Meggitt 1926. From the former the present form can be distinguished by the much larger number of rostellar hooks: from the latter, by its smaller size, the smaller size and relatively smaller extent of the cirrus sac, the much more coiled vas deferens and the less lobed ovary: from both by the different systematic positions of the hosts.

R. flaminiata n.sp.

Host: *Columba punicea* (Tickell 1842): *Goura coronata* (L.).

Maximum length 50, maximum breadth 0·6. Scolex 0·72 dia. Rostellar hooks 0·009 long. Genital pore unilateral, at anterior third of proglottis margin. Cirrus sac 0·11–0·13 × 0·04–0·06 in mature proglottides, reaching ventral longitudinal excretory vessels. Testes 5–9, usually 2 poral and the remainder aporal. Egg capsules approximately 16 in each proglottis, separated by large areas of parenchyma, not extending laterally to excretory vessels, and each containing 2–6 (usually 2) eggs. The small number of testes and egg capsules form the justification for the creation of a new species.

R. fragilis n.sp.

Host: *Columba punicea* (Tickell 1842).

Six strobilae were found in the intestine. Maximum length 190, maximum breadth 0·9. Scolex 0·15 dia. Rostellum 0·073 dia.: rostellar hooks 0·006–0·009 long. Suckers armed with several rows of hooks. A spiny collar present posteriorly to rostellum. Genital pore unilateral, in centre of proglottis margin. Cirrus sac 0·12 × 0·06 in mature proglottides, smaller posteriorly, never extending to longitudinal nerve. Testes 6–7 aporal, 2 poral, lateral to female glands. Egg capsules approximately 75, each containing 4–6 eggs, and extending laterally to excretory vessels.

The small number of testes, together with the unilateral genital pore and the number of eggs per capsule, distinguishes this species from all others of the same genus except *R. ceylonica* (Baczynska 1914) from which it is separated by the central position of the genital pore, the relatively smaller size of the cirrus sac, the fewer eggs in each capsule, and the arrangement and (?) number of the testes.

R. friedbergi (Linstow 1877).
(Fig. 2.)

Host: *Pavo cristatus* L. 1766.

Several strobilae were found in the intestine. Scolex absent. Maximum length 117, maximum breadth 1. Genital pore in anterior quarter of proglottis margin, on a rather prominent genital papilla. Testes approximately 31, posterior, lateral and, on aporal side, anterior to female glands. The arrangement and appearance of these are very different from those figured by Baczynska (1914, p. 201, Fig. 25), but may be due to different states of contraction. Cirrus sac 0·048–0·075 × 0·025–0·033 in mature segments, extending to nerve. All genitalia disappear quickly, the strobilus mostly consisting of gravid proglottides. Egg capsules 74–90 in each proglottis, each containing 6–10 eggs: they extend laterally to the longitudinal excretory vessels and are more closely packed together than in the centre of the proglottis.

The above description differs from that of Baczynska in a few details, but not sufficiently to justify the creation of a new species.

R. pseudocyrtus sp.dub.

Host: Duck.

Maximum length 70, maximum breadth 1·2. Scolex absent. Genital pore unilateral, anterior to centre of proglottis margin. Cirrus sac, in mature proglottides, 0·053–0·062 × 0·041, in gravid ones 0·05–0·053 × 0·047, extending to longitudinal nerve. Testes 25–32. Ovary very poral. Egg capsules each contain 6–8 eggs and extend laterally to longitudinal excretory vessels.

The number of eggs in each capsule distinguishes this form from *R. anatina*, *R. microcotyle*, and *R. parviuncinata*, the number of testes, poral position of the ovary and size of cirrus sac from *R. cyrtus*. The present form thus cannot be placed in any species hitherto recorded from Anseriformes. The absence of a scolex renders a definite identification impossible, sufficient marks of demarcation from other species of this genus not existing: the form is therefore listed as a dubious species.

R. quadritesticulata Moghe 1925.

Host: *Chalcophaps indica* (L. 1766): *Goura coronata* (L. 1766).

The present species differed from Moghe's description (1925, p. 433) in the following points. Maximum length 320, maximum breadth 2. Rostellar hooks 0·008 long. A spiny collar present posterior to rostellum. Testes 4–7. Egg capsules in surface view 47–56, total 60–100. It will be observed that the differences are slight except for the number of egg capsules: this latter may be accounted for by the difficulty of counting several layers of capsules and the possibility of omitting a portion of a layer. It was at first thought that this species and *R. torquata* (Meggitt 1924) were identical, but examination of the material of the latter showed the great discrepancy in the number of the capsules: otherwise *R. quadritesticulata* falls into synonymy with *R. torquata*.

R. sp.

Host: Woodpecker.

Maximum length 8, maximum breadth 0·6. Scolex 0·26 dia. Rostellar hooks 0·006 long. Suckers armed. Genital pore unilateral, at anterior third of proglottis margin. Cirrus sac 0·059–0·05 × 0·031 in mature segments, not reaching ventral longitudinal excretory canals. Testes 12–16. Gravid proglottides absent. As the present form does not agree with any recorded from Piciformes and does not possess characters sufficient to differentiate it from other species from different groups it is left unnamed. Locality of host: Pyinmana.

R. sp.

Host: *Goura coronata* (L. 1766).

Scolex and gravid proglottides absent. Genital pore unilateral, slightly posterior to centre of proglottis margin. Cirrus sac 0·085 × 0·053, extending to longitudinal excretory vessels. Testes 5, 2 poral and posterior to genital ducts, 3 aporal.

Raillietina is the only genus with unilateral genital pores recorded from Columbiformes. Of the species described from that group the only ones with few testes are *R. ceylonica* (Baczynska 1914), *R. cryptacantha* (Fuhrmann 1908), *R. fuhrmanni* (Southwell 1922), *R. gendrei* Joyeux 1923, *R. spiralis* (Baczynska 1914), *R. torquata* (Meggitt 1924), and *R. weissi* Joyeux 1923, and of these none agrees with the above characters. As the description is so inadequate the form is left unnamed.

Sub-family IDIOGENINAE Fuhrmann 1907.

Idiogenes Krabbe 1869.

I. flagellum (Goeze 1782).

Host: *Milvus melanotis*.

A single immature specimen, devoid of scolex.

Family HYMENOLEPIDIDAE Railliet and Henry 1909.

Sub-family DILEPININAE Fuhrmann 1907.

Amoebotaenia Cohn 1899.

A. sphenoides (Railliet 1892).

Host: Duck.

The first record of this species from Anseriformes. The specimens agreed in all respects with those from fowls.

Choanotaenia Railliet 1896.

C. infundibuliformis (Goeze 1782).

Host: *Milvus govinda* Sykes 1832.

Gryporhynchus Nordmann 1832.

G. macropeos (Wedl 1856).

(Fig. 3.)

Host: *Ardeola grayii* (Sykes 1832).

Intestine of host swarming with parasites. Maximum length 2·5, maximum breadth 0·3. Scolex 0·11–0·14 dia. Rostellum 0·07–0·09 dia., armed with 20 hooks in two rows: those of one row 0·026–0·028, of the other 0·045–0·049 long. Genital pore at anterior third of proglottis margin. Cirrus sac 0·132–0·175 × 0·037–0·042, extending across the whole proglottis. Testes 5, posterior and lateral to female glands, extending past excretory vessels. Vitelline gland often very aporal. Gravid proglottides absent. The sizes of the hooks do not agree with those given by Krabbe (1869, p. 279—0·04 and 0·023): the difference is not, in view of the incomplete knowledge of this species, sufficient to justify the creation of a new species.

Sub-family HYMENOLEPIDINAE Ransom 1909.

Hymenolepis Weinland 1858.

H. bacillaris (Goeze 1782).

Host: *Crocidura caerulea* (Kerr 1792).

Maximum length 9, maximum breadth 0·27. Scolex 0·17 dia. Rostellum 0·11 dia., rostellar hooks 46, 0·02 long. Genital pore at anterior third of proglottis margin. Cirrus sac 0·06 × 0·02, extending past excretory vessels, approximately one-third across proglottis. Testes large, occupying the whole surface of the proglottis, arranged in the form of an equilateral triangle with the apex median and anterior. Gravid proglottides absent.

H. decipiens (Diesing 1850) from Chiroptera is probably synonymous with this species. The hooks of the two forms are similar in shape and differ only slightly in size and number (36, 0·02; 40, 0·023). These differences appear insufficient to justify the separation of the two forms.

? H. biaculeata Fuhrmann 1909.

Host: *Alopochen aegyptiacus* (L. 1766).

H. clausa Linstow 1906.

Host: *Dendrocygna javanica* (Horsfield 1821).

Cirrus sac 0·21–0·23 × 0·077–0·047, extending half-way across proglottis or, in young segments, nearly to aporal excretory vessels. Testes usually in the same straight line but rather variable in position.

H. coronula (Dujardin 1845).

Host: *Dendrocygna javanica* (Horsfield 1821).

H. furcata (Stieda 1862).

Host: *Crocidura caerulea* (Kerr 1792).

H. zosteropis Fuhrmann, 1918.

Host: *Garrulax albogularis* (Gould 1835).

Rostellar hooks 0·032–0·033. One aporal testis anterior and slightly external to the other, 0·18–0·21 × 0·15–0·19. Cirrus sac in mature proglottides 0·088–0·1 × 0·049–0·06, in gravid 0·08 × 0·048, extending internally to longitudinal excretory vessels. Otherwise the specimens agreed with the description of Fuhrmann (1918, p. 441). In view of the great variability in size of the structures mentioned the discrepancies are not of sufficient importance to justify the creation of a new species. *H. corvi* (Mayhew 1925, p. 62) does not appear to be distinguishable from the present species, the points mentioned by the author being small and of dubious stability.

H. sp.

Host: *Treron nipalensis*.

Maximum length 12, maximum breadth 0·5. Scolex absent. All proglottides immature, with but rudiments of genital organs. One aporal testis anterior and external to the other.

H. sp.

Host: *Pitta brachyura* (L. 1766).

Maximum length 3, maximum breadth 0·18. Scolex 0·33 dia. Rostellum 0·12 dia. Hooks absent. No signs of genital organs. No cestode has previously been recorded from this host.

Family MESOCESTOIDIDAE Fuhrmann 1907.

Dithyridium Rudolphi 1819.

The position of this genus, composed wholly of larval forms, in the family is dubious and depends on the work of Skrjabin and Schulz (1926) in connection with forms from the mouse. The majority of forms found in Burma are encysted in the intestinal mesentery of various snakes, and so far feeding experiments have failed to identify the adult. In many cases the numbers in a single host are exceedingly great, while certain snakes (*e.g. Rhabdophis stolatus, Simotes cruentatus*) are never unparasitised. In structure the larva is a solid mass of parenchyma, generally surrounded by three coats of fibrous material, with a head provided with four suckers and an anterior muscular mass similar to an unarmed rostellum. Often the larvae are aggregated into clumps, joined together like a bunch of grapes, and possibly affording an explanation of the form *Staphylocystis glomeridis* described by Villot (1881). As no structural difference between the various forms can be found, the hosts only are given: *Chrysopelea ornata* (Shaw 1802), *Simotes purpurascens* (Schlegel 1837), *Naja naja* (L. 1758), *Natrix piscator* (Schneider 1799), *Bungarus candidus multicinctus* Blyth 1861, *Natrix beddomei* (Günther 1864) and *Simotes cruentatus* Günther 1868, are fresh records. Altogether these forms have now been recorded from 15 species of Burmese snakes.

D. sp.

Host: *Milvus govinda* Sykes 1832.

In small cysts, 1·0 dia. in the intestinal wall. The wall consisted of several layers, apparently derived from the host, with several internal concentric rings of a clear substance similar to that described for *Sparganum* sp. from a mongoose (Meggitt 1924, p. 52). Inside the rings was a larval form, devoid of suckers or rostellum, but possessing calcareous corpuscles. The following larval forms have been recorded from Accipitriformes: *Bothriocephalus falconis* (Rudolphi 1819) from *Falco* sp., and *Diphyllobothrium reptans* (Diesing 1850) from *Pandion haliaëtus*. Larval forms such as the present cannot be distinguished one from another. As the present specimens may belong to either of the above species, which in turn may be synonyms of one another, or be entirely separate, it is best to leave them unnamed. To determine the final host is a matter of some difficulty: it is not readily comprehensible what species normally eats kites. Possibly the larvae are pseudoparasites, living in the wrong host.

Mesocestoides Vaillant 1863.

M. tenuis n.sp.

Host: Dog.

A few strobilae from the fresh faeces of a puppy six weeks old. Maximum length 150, maximum breadth 0·9. Scolex and more anterior proglottides absent. Genital pore slightly anterior to centre of proglottis margin: genital cloaca simple, not forked. Testes in two entirely separate rows, a single distinct band lateral to excretory vessels each side, in number 14–18 each side. Cirrus sac not reaching anterior third of proglottis length, slightly lateral, directed anteriorly, internally. Centre of proglottis occupied by uterus and female glands. Uterus a slightly coiled sac, ending in a small egg sac occupying —when mature—only the centre third of the proglottis transversely and the posterior third longitudinally, 0·46–0·49 × 0·3–0·34. Eggs 0·035–0·044 × 0·3–0·035. Onchosphere nearly filling shell.

Of the species of *Mesocestoides* no adequate description exists of *M. ambiguus* Vaillant 1863, *M. angustatus* (Rudolphi 1810)—probably a synonym of *M. lineatus*—*M. magellanicus* (Monticelli 1889), *M. latus* Mueller 1927 and *M. variabilis* Mueller 1927. From *M. lineatus* (Goeze 1782), *M. mesorchis* Cameron 1925, *M. michaelsenii* (Lönnberg 1896) the present form is distinguished by the small number of testes and their complete division into two lateral bands, from *M. bassarisci* MacCallum 1921 by their extension laterally to the excretory vessels. The large size of the cirrus sac, reaching the anterior border of the proglottis, characterises *M. elongatus* Meggitt 1928. From *M. caestus* Cameron 1925 the specimens are distinguished by the presence of testes in the central field, the larger ova, fewer testes external to the excretory vessels, their smaller number, and the more posterior position of the egg capsule. *M. charadrii* Fuhrmann 1909 has the majority of the testes external

to the excretory vessels and so cannot be confused. *M. longistriatus* (Setti 1897) is dismissed by the larger size and relative position of the cirrus sac, the smaller size of the egg capsule, the larger number of testes and their anterior junction. The only remaining species are *M. alaudae* Stossich 1896 and *M. perlatus* (Goeze 1782), both from birds, the descriptions of which are inaccessible in Rangoon.

Family NEMATOTAENIIDAE Lühe 1910.

Cylindrotaenia Jewell 1916.

C. americana Jewell 1916.

(Fig. 4.)

Host: *Ptyas mucosus* (L. 1758).

The first record of the occurrence of this species was from American frogs (*Acris gryllus* and *Rana pipiens*), the second (Joyeux 1924, p. 235) from *Arthroleptis ogoensis* and *Rana aequiplicata* from Portuguese East Africa. The specimens agreed in all respects with the description of Jewell except that the egg varied from 0·013–0·016 dia., instead of 0·012–0·014, and the cirrus sac was nearly spherical, 0·022 × 0·022–0·027, instead of 0·036–0·044 × 0·013–0·017. Mature eggs 1–6 in each portion of the paruterine organ. This is the first record of the occurrence of this species from a reptile.

Unidentified species.

Host: *Eos variegata* (Gmelin 1788).

Length 17, greatest breadth 0·3. Scolex 0·47 dia., devoid of rostellum. All proglottides immature, without signs of genital organs. The only cestode from this host is *Raillietina microscolecina* (Fuhrmann 1908), while too many species without a rostellum have been collected from Psittaciformes to afford any indication of the identity of the present form.

Host: *Milvus govinda* Sykes 1832.

Maximum length 0·9, maximum breadth 0·2. Scolex 0·325 dia. Rostellum 0·09 dia., armed with 10 hooks 0·046 long (Fig. 4). All proglottides immature. The shape and size of the hooks do not agree with anything recorded from Accipitriformes: the present species, in view of the incomplete anatomy, is therefore left unnamed.

Slossia new collective group.

S. crociduriana n.sp.

Host: *Crocidura murina* (L. 1766).

A single specimen found. Length 1·26, breadth 0·27. Scolex 0·38 dia. Suckers four, 0·01–0·015 dia. Rostellum absent. No trace of segmentation or of genital organs. No such form has previously been recorded from Insectivora. Several species with unarmed scoleces have been described from

the group: it is therefore impossible to place the present form with any certainty. To include it in the genus *Taenia s.l.* is equally impossible by reason of its unarmed scolex, together with the undesirability of transforming that genus into a heterogenous assembly of unrelated forms. The genus, or collective group, *Scolex* Müller 1787 was created for forms from fish, presumably different from the present case. The collective group *Slossia* is therefore proposed for immature Cyclophyllidea, devoid of segmentation, rostellum and genitalia, and provided with four evaginated suckers.

PSEUDOPHYLLIDEA.

Family DIPHYLLOBOTHRIIDAE Lühe 1910.

Sub-family DIPHYLLOBOTHRIINAE Lühe 1910.

Bothridium Blainville 1824.

B. sp.

Host: *Naja naja* (L. 1758).

Two specimens encysted in the mesentery. Largest 2·8 long, 0·9 broad, scolex 1·05 dia.; bothridia two, of the same shape as that of the mature form. The occurrence of the encysted form in this host, the only one in which I have found it in Burma, suggests the possibility of the cobra falling a prey to the python. In another dissection the larval forms were found in the lung and on the dorsal aorta. In this case the two bothridia were sunk into the scolex.

Diphyllobothrium Cobbold 1858.

D. reptans (Diesing 1850).

Host: *Felis bengalensis* Kerr 1782: cat.

Larval stages of this form were also found in *Cerberus rhynchops* (Schneider 1799) and have been recorded from 11 species of Burmese snakes.

Duthiersia Perrier 1873.

D. fimbriata (Diesing 1850).

Host: "Large lizard" in Upper Burma.

Family BOTHRIOCEPHALIDAE E. Blanchard 1849.

Polyonchobothrium Diesing 1854.

P. clarias (Woodland 1925).

Host: Fish, genus unknown.

Four immature specimens were found. All agreed with the description of Woodland (1925, p. 719).

TETRAPHYLLIDAE.

Family PROTOCEPHALIDAE La Rue 1911.

Crepidobothrium Monticelli 1899.

C. fictum n.sp.

(Figs. 5 and 6.)

Host: *Xenopeltis unicolor* Reinwardt 1827.

Length 50, breadth 0·8. Scolex 0·79–1·0 transverse diameter, 0·59–0·83 dorso-ventrally, provided with four suckers sunk within four spherical lobes nearly constricted off from the true scolex. This type of scolex approximates more to the *Phyllobothrium* (cf. *Pithophorus* Southwell 1925, p. 245, Fig. 152) type than to the *Crepidobothrium*. Cirrus sac 0·021–0·023 × 0·012–0·017, passing excretory vessels and extending approximately one-third of the transverse diameter of the proglottis. Testes 51–61, 23–30 poral, 28–31 aporal, each 0·043–0·059 dia., in two lateral strands, clearly separated even before the appearance of the uterus. Vaginal pore usually posterior to cirrus sac, occasionally anterior. Uterine diverticulae 31–35. Referring to a key previously given (Meggitt 1927, p. 79) it may be seen that the present form falls within group G, from all the species of which it may be separated by the shape of the scolex and the combination of the numbers of testes and uterine diverticulae. It may be noted that in the same group *C. schultzei* (Hungerbühler 1910) is stated to have the vagina always posterior to the cirrus sac. In the Burmese form the anterior position of the vagina is only occasional and easily overlooked: such may be also the case with the African form and the recorded invariable position be due to inaccuracy of observation.

C. mönnigi (Fuhrmann 1924).

Host: *Natrix piscator* (Schneider 1799): *Simotes purpurascens* (Schlegel 1837).

The form differed from the original description in the possession of 46–50 testes instead of 50–70.

C. najae (Beddard 1913).

Length 140, breadth 2. Scolex 0·25 dia. Genital pore at centre of proglottis margin, vagina mostly anterior to but occasionally posterior to cirrus sac. Testes 68–72 poral, 82–93 aporal, total 150–165: in two clearly separated groups, each subdivided into an outer row immediately adjacent to the vitellaria and an inner group of greater extent: dia. 0·077–0·095. Cirrus sac in mature proglottides 0·39–0·41 × 0·077–0·095, in gravid 0·58 × 0·12–0·15, passing longitudinal excretory vessels and extending one-fifth to one-fourth across the proglottis, containing many coils of the vas deferens. Ovary transversely elongated, narrow antero-posteriorly, touching both rows of vitellaria. Uterine diverticulae 14–18 each side, without glandular walls. On ventral surface a longitudinal split of varying extent, or 2–3 small holes without definite walls, communicating internally with the uterus.

The only species of this genus recorded from the cobra is *C. najae*, unfortunately so badly described that hardly one diagnostic character is given. The above description agrees in the main with that of Beddard (1913 *a*, p. 25), the differences—presence of a shell gland and absence of uterine glandular walls—being possibly due to imperfect fixation of the material of that investigator. As in both cases the host and the locality are the same, the absence of any morphological character separating the two forms precluded the possibility of creating a new species: the form is therefore listed as *C. najae*.

C. russelli (Beddard 1913).

Host: *Vipera russellii* (Shaw 1827).

A single specimen. Length 260, maximum breadth 3. Scolex 0·35 dia. Genital pore at centre of proglottis margin, vagina anterior or posterior to cirrus sac, usually the former, devoid of a sphincter. Cirrus sac in immature proglottides elongated and narrow, latter globular, 0·34–0·4 × 0·12–0·16 extending to excretory vessels and occupying one-fifth of proglottis width. Testes 128–135. No fully mature proglottides seen.

The original description of *C. russelli* is inadequate for identification. The present form is listed under that name by reason of the similarity in hosts and such characters as were given.

C. sp.

Host: *Naja naja* (L. 1758).

A single immature specimen from the intestine. Length 1·78, breadth 0·2. Scolex 0·31 dia. Suckers very large and bulbous. Two large excretory vessels, 0·04 dia., running from scolex to open by a single stem at the posterior end of strobilus.

C. sp.

Host: *Natrix beddomei* (Günther 1864).

A single immature specimen, 9 long and 0·6 broad, with an invaginated scolex provided with four suckers.

TRYPANORHYNCHA.

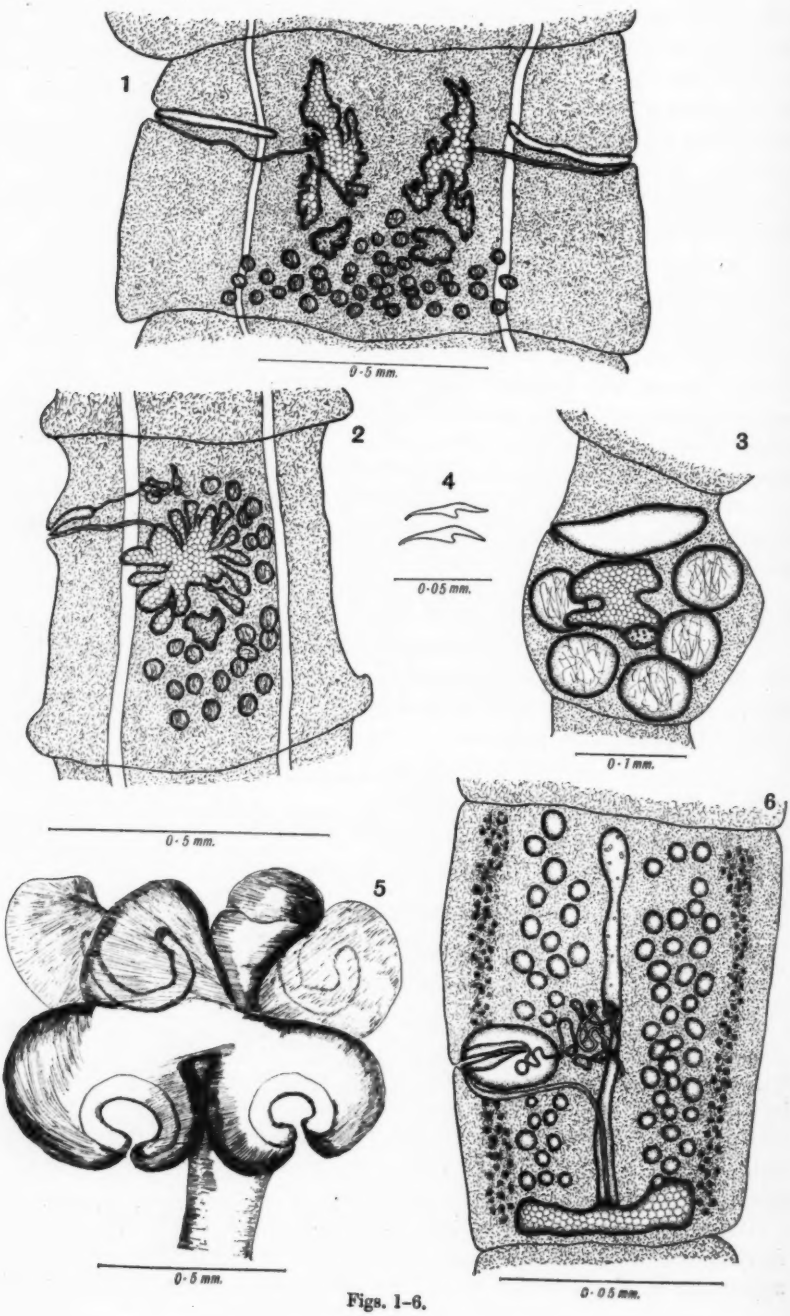
Tetrarhynchus Rudolphi 1809.

T. incognitus sp.dub.

Host: *Cerberus rhynchops* (Schneider 1799).

Encysted in large translucent cysts in the mesentery. Inside primary cyst a secondary thin-walled one, 9 long and 2·1 wide at its widest part, divided into a long thin tail and a large anterior portion, bladder-like in appearance, 3·5 long and 2·1 wide, containing a small larva. Latter 7 long and 0·3 wide, with an anterior scolex 0·8 dia., provided with four proboscides not yet opening to the exterior: proboscis bulbs two.

Only one species of Trypanorhyncha (*Tetrarhynchus* sp. Shipley 1903 from *Enhydrina schistosa*, Siam) has been recorded from Ophidia. In general appearance Shipley's species agrees with the present form, Shipley having



Figs. 1–6.

mistaken the secondary cyst for the body of the cestode. For the facilitation of reference the name *T. incognitus* is proposed for the present form, not as any indication of specific value.

Types of *Cotugnia fila*, *Raillietina fecunda*, *R. flaminiata*, *R. fragilis*, *Mesocestoides tenuis*, *Crepidobothrium fictum*, and *Tetrarhynchus incognitus* are deposited in the British Museum (Natural History), London; Bureau of Animal Industry, Washington; Molteno Institute for Parasitology, Cambridge; and Laboratoire de Parasitologie, École de Médecine, Paris.

LEGENDS TO TEXT-FIGURES.

Fig. 1. *Cotugnia fila* n.sp. (see text, p. 250).
Fig. 2. *Raillietina friedbergi* (see text, p. 253).
Fig. 3. *Gryporhynchus macropeos* (see text, p. 255).
Fig. 4. *Cylindrotaenia americana* (see text, p. 258).
Figs. 5 and 6. *Crepidobothrium fictum* n.sp. (see text, p. 260).

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(*MS. received for publication* 9. II. 1931.—Ed.)

MATÉRIAUX POUR LA CONNAISSANCE DES DIPTÈRES PUPIPARES. I.

PAR L. FALCOZ.
Vienne en Dauphiné.

(Avec 5 figures dans le texte.)

PARMI le nombre des Diptères Pupipares de provenances diverses que j'ai eu l'occasion d'étudier récemment, certains, jugés nouveaux, seront décrits ici, d'autres, déjà connus, mais offrant quelque intérêt aux divers points de vue systématique, éthologique ou géographique, feront l'objet d'une mention spéciale.

HIPPOBOSCIDAE.

Lipoptena capreoli Rondani.
(Fig. 1.)

1878. *Lipoptena capreoli* Rondani, *Ann. Mus. civ. Genova*, **12**, 152.
1879. *Lipoptena capreoli* Rondani, *Boll. ent. Soc. Ital.* **11**, 14.

Matériel étudié.—1 ♂ pourvu de mognons alaires, sans indication d'hôte. Cattaro, côte orientale de l'Adriatique (G. Rousseau). Muséum de Bruxelles.

Fig. 1. A. *Lipoptena capreoli* Rond. Tête, face dorsale. B. *Lipoptena cervi* L. Tête, face dorsale.

Observations.—Speiser (*Fasciculi Malayenses*, Zool. **1**, 1903, p. 51) a émis des doutes sur la validité de cette espèce, mais l'existence du spécimen du Muséum de Bruxelles, conforme à la description de Rondani, montre qu'il s'agit bien là d'une espèce valable.

Les principaux caractères qui distinguent *L. capreoli* Rond. de *L. cervi* L. sont les suivants:

Taille moindre: 3–3,2 mill. au lieu de 5,2–5,8 mill.

Yeux proportionnellement plus petits. Chez *L. capreoli*, la largeur d'un œil est égale au cinquième de la largeur totale de la tête, tandis que cette même dimension est égale au quart chez *L. cervi*.

Le post-vertex (triangle ocellaire) est nettement plus long et plus convexe en avant chez *L. capreoli* que chez *L. cervi*, il en résulte que le médio-vertex (aire frontale) est considérablement plus court chez le premier que chez le second.

La chaetotaxie thoracique paraît présenter peu de différences chez les deux espèces.

D'après Rondani, dans la femelle de *L. capreoli*, la face dorsale de l'abdomen est de couleur pâle, la base seule est foncée, et on n'observe pas les trois scuta foncés et brillants qui existent dans la femelle de *L. cervi*.

STREBLIDAE.

Raymondia javanica n.sp.
(Figs. 2 et 3.)

Matériel étudié.—Holotype: 1 ♀, sur *Nycteris javanica*, Java. Ma collection.

Longueur: 1,8 mill. (sur lame).

Tête aussi large que la portion antérieure du thorax, à côtés arrondis; palpes petits, courts; sous-régions du vertex bien distinctes, chacune des moitiés épicraniennes (latéro-vertex) nettement séparées l'une de l'autre par la bande frontale (médio-vertex), prolongée elle-même en arrière par une aire en triangle surbaissé (post-vertex), cette dernière munie, dans le milieu du bord postérieur, de deux courtes soies spinuliformes; sur chaque moitié épicranienne sont implantées de nombreuses soies, petites en avant et sur les côtés, assez longues vers la marge postérieure et près des bords latéraux; gènes et post-gènes revêtues de soies courtes; théca du labium environ trois fois plus large que longue.

Thorax légèrement plus long que large; processus huméraux peu développés, portant deux soies fortes et plusieurs autres plus petites; préscutum revêtu de fines soies pâles, peu serrées; scutum offrant en avant quelques soies fines et des soies plus fortes, celles-ci disposées: deux au milieu, deux de chaque côté, près des bords latéraux; scutellum orné de soies brunes: deux longues paramédianes, dix à douze marginales.

Sternum uniformément revêtu de fines soies, courtes, peu serrées; chacune des sternopleures est environ une fois et demie plus longue que large.

Pattes sans caractères distinctifs.

Ailes à alula rudimentaire, pourvue d'une unique soie distale; nervure humérale pourvue de deux soies; on observe des sétules dans les cellules costale, marginale et submarginale, ainsi que dans les 1ère et 3e cellules postérieures;

4° nervure longitudinale nettement infléchie postérieurement, entre $r-m$ et $M\ 3 \times 4$.

Abdomen à lobes latéraux de la base étroits, ornés de quatre longues soies: deux postérieures, deux latérales, deux petites soies spinuliformes se trouvent en outre en dedans et au niveau des soies latérales.

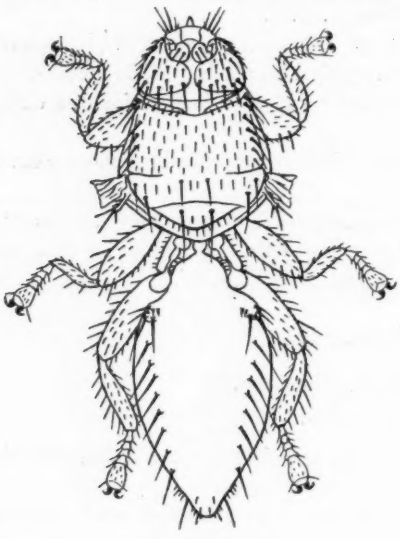

Fig. 2.

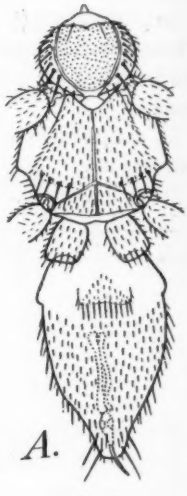

Fig. 3.

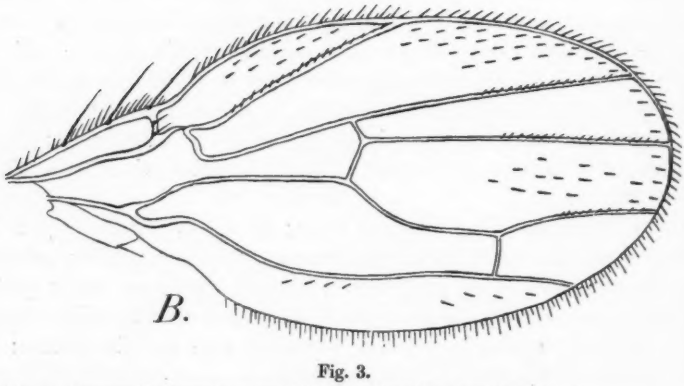

Fig. 3.

Fig. 2. *Raymondia javanica* n.sp. Mâle, sans les ailes, face dorsale.
Fig. 3. *Raymondia javanica* n.sp. A. Mâle, sans les ailes, face ventrale. B. Aile.

Genitalia ♂, vus par transparence, offrant l'aspect représenté fig. 3, *A*.

Affinités.—Cette espèce appartient au groupe des *R. lobulata* Speiser et *R. planiceps* Jobling, à tête arrondie latéralement, aussi large que le thorax et à théca plus large que longue. Elle diffère de *R. lobulata* par la sétulation

uniforme des sternopleures mésothoraciques. On la distingue en outre de *R. lobulata* et de *R. planiceps* par la plus grande largeur de la théca, par divers détails de chaetotaxie et, notamment, par la sétulation et la nervulation nettement différentes des ailes.

Paradyschiria parvula n.sp.
(Figs. 4 et 5.)

Matériel étudié.—Holotype: 1 ♂, sur *Dirias albiventer*, Brésil. Ma collection.

Longueur: 1,4 mill. (sur lame).

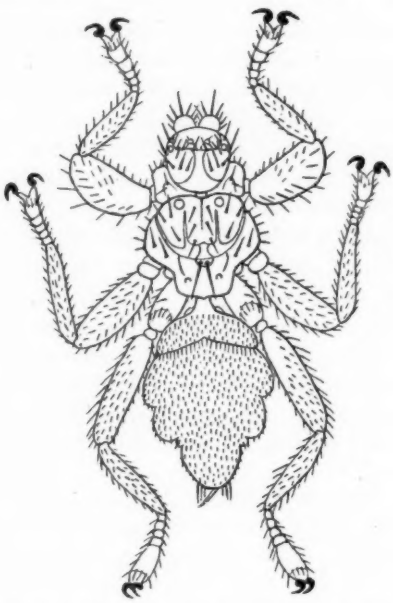

Fig. 4. *Paradyschiria parvula* n.sp. Mâle, face dorsale.

Tête arrondie et convexe; yeux ocellaires, de grandeur moyenne; palpes lamelliformes, à bord antérieur arrondi et bordé d'assez fortes soies; sous-régions du vertex assez distinctes; moitiés épicraniennes (latéro-vertex) nettement sclérifiées, portant chacune trois soies postérieures et cinq à six soies antérieures, ces dernières disposées au niveau et en dedans des yeux; les moitiés épicraniennes sont assez largement séparées par la bande frontale (médio-vertex), elle-même prolongée en arrière, sans délimitation précise, par le triangle vertical (post-vertex). Gènes portant quelques soies sur leur région dorso-latérale, glabres sur la région ventrale; post-gènes également glabres, sauf sur la marge interne qui est sétuleuse; théca du labium en triangle arrondi.

Thorax offrant les dispositions habituelles du genre, c'est-à-dire: pré-

scutum divisé longitudinalement en trois aires sclérifiées; une médiane oblongue, deux latérales subtriangulaires; la suture transverse, assez large, émet en avant quatre prolongements qui délimitent les aires sclérifiées du préscutum; l'aire médiane porte six poils disposés en deux rangées longitudinales; les aires latérales en supportent chacune trois; stigmates mésothoraciques très grands, situés en avant et légèrement en dehors du sommet des deux prolongements paramédians de la suture transverse; le scutum semble avoir disparu, peut-être est-il remplacé par un petit sclérite en forme de sablier qu'on observe contre le bord postérieur de l'aire préscutale médiane; scutellum très petit, orné de deux fortes et longues soies; dorso-pleures très développées et portant quelques soies.

En arrière du scutellum, il existe deux légères saillies en forme de bouton, représentant vraisemblablement des vestiges d'haltères.

Branches de la suture méso-métasternale dessinant un angle très ouvert.

Pattes sans caractères distinctifs. Comme chez les autres espèces du genre, les hanches antérieures montrent dorsalement une saillie conique pourvue de deux soies assez fortes. Fémurs antérieurs renflés.

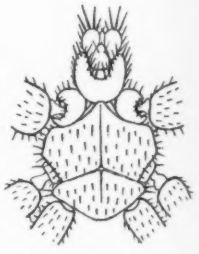

Fig. 5. *Paradyschiria parvula* n.sp. Mâle, tête et thorax, face ventrale.

Abdomen présentant, sous forme de bourrelets latéraux, des traces évidentes de métamérisation. Tergite basal transverse, plus de deux fois aussi large que long, à bord postérieur frangé de soies fines à peine plus fortes et plus longues que celles du disque. Surface de l'abdomen uniformément couverte dorsalement et ventralement de soies fines, courtes, assez serrées; près du sommet, quelques soies assez longues garnissent le pourtour de l'orifice génital.

Genitalia du ♂ composés d'une pièce médiane pointue au sommet, flanquée, à son issue de l'abdomen, de deux valves allongées, assez robustes. L'ensemble offre une grande analogie avec l'armure copulatrice externe de la plupart des *Hippoboscidae*.

Affinités.—*Paradyschiria parvula* est très voisin de *P. lineata* Kessel dont il ne représente peut-être qu'une sous-espèce. Il s'en distingue cependant par la taille nettement plus petite, la sétulation marginale du tergite basal de l'abdomen bien plus fine, enfin par la présence des bourrelets latéraux de l'abdomen. Je n'ai pas observé ces derniers sur une série d'individus de *P. lineata* que j'ai examinés, grâce à l'extrême obligeance de M. Edwards, du British Museum, que je tiens à remercier ici.

NYCTERIBIIDAE.

Penicillidia leptothrinax Speiser.

1908. *Penicillidia leptothrinax* Speiser. Voeltzkov, *Reise in Ostafrika*, **2**, 199, figs. 1–2.

Matériel étudié.—1 ♂, Madagascar, sur *Miniopterus scotinus*. Ma collection.

Observations.—Découvert à Madagascar sur *Miniopterus* sp.

Nycteribia (Celeripes) biarticulata Hermann.

1804. *Nycteribia biarticulata* Hermann, *Mémoire aptérologique*, p. 194.
1926. *Nycteribia* (*Celeripes*) *biarticulata* Hermann. Falcoz, *Faune de France*, **14**, Diptères Pupipares, p. 48, figs. 64, 65, 67 et 69.
1926. *Nycteribia* (*Stylidia*) *biarticulata* Hermann. Jeannel, *Faune cavernicole de la France*, p. 316.

Matériel étudié.—♂ et ♀, Banyuls-sur-Mer, sur *Vespertilio murinus*. Laboratoire de Parasitologie de la Faculté de Médecine de Paris.

Observations.—Cette espèce, bien qu'affectionnant les Chauve-souris solitaires (Rhinolophides), peut aussi parfois parasiter les Chiroptères à mœurs grégaires (Vespertilionides).

Nycteribia (Listropodia) Schmidli Schiner.

1853. *Nycteribia Schmidli* Schiner, *Zool. bot. Ver.* **3**, 151.
1926. *Nycteribia* (*Listropodia*) *Schmidti* [*sic*] Schiner. Falcoz, *Faune de France*, **14**, Diptères Pupipares, p. 51, figs. 73–76.
1926. *Nycteribia* (*Listropodia*) *Schmidti* [*sic*] Schiner. Jeannel, *Faune cavernicole de la France*, p. 317.

Matériel étudié.—♂ et ♀. Côte d'Or, sur *Rhinolophus ferrum-equinum*.

Observations.—Le *Rhinolophus ferrum-equinum* n'avait pas encore été signalé comme hébergeant le *N. Schmidli* dont les hôtes précédemment connus sont les suivants: *Rhinolophus Mehelyi*, *Myotis Daubentoni*, *M. myotis*, *Vespertilio pipistrellus*, *Miniopterus Schreibersi*.

Cyclopodia dubia Westwood.

1835. *Nycteribia dubia* Westwood, *Trans. Zool. Soc. London*, **1**, 289.
1901. *Cyclopodia dubia* Westwood. Speiser, *Arch. f. Naturg.*, separ. p. 54.

Matériel étudié.—♂ et ♀, Madagascar, sur *Pteropus Dupreanus*. Ma collection.

Observations.—Cette espèce de *Cyclopodia* était connue jusqu'ici d'un *Pteropus* sp., sans désignation spécifique.

(*MS. received for publication* 9. I. 1931.—Ed.)

NOTE ON THE TICK *ORNITHODORUS TALAJE* (GUÉR.-MÉN.).

By ROBERT MATHESON.
Cornell University.

On 9. I. 1928, Mrs R. A. Neuman of Ransomville, N.Y., sent me a tick for identification, stating that it was a kind of "bug" with which she was not familiar and that it was occasionally found on the walls of her home. She collected in all about six specimens, but sent me only one, which proved to be an *Ornithodorus talaje* (Guérin-Méneville), my identification having been since confirmed by Professor Nuttall and Mr Warburton.

Mrs Neuman has informed me recently that her family, some sixteen years ago, brought a suite of bedroom furniture from San Antonio, Texas, where it had been in storage for a year. She found the first tick only three years ago and since then has taken at least one tick in every room in the house and in the hall. The ticks were always found crawling on the walls. She states they are very sluggish even in the warmest weather and "when touched act like a turtle, drawing up their legs and are very still." Hitherto this tick has been recorded only from the extreme southern parts of the United States and in sub-tropical and tropical countries.

Therefore this interesting capture seems worthy of record. Here is a tick certainly not common or abundant (judging from the published records) in any part of the United States and yet some six specimens are collected both in summer and mid-winter on the walls of a home in western New York. How this tick reached there can only be surmised. It probably maintained itself in the heated house and fed on the occupants or more probably on mice or rats or the domestic cat and dog though none of these is listed as its normal host. Mrs Neuman did not say that members of the household were ever troubled by its bite. All records seem to agree that its bite is severe and painful. This record shows that this tick, normally occurring in warm climates, can maintain itself in a heated house in a northern climate.

(MS. *received for publication* 28. II. 1931.—Ed.)

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PARASITOLOGY is published about four times a year. The numbers afterwards are issued in volumes each containing four numbers.

Papers for publication should be sent to Professor GEORGE H. F. NUTTALL, F.R.S., Longfield, Madingley Road, Cambridge. Other communications should be addressed to the University Press, Cambridge.

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The Cambridge University Press has appointed the University of Chicago Press agent for the sale of *Parasitology* in the United States of America and has authorised the following prices: Subscription $13.25 net per volume; single numbers $4.55 net each, double numbers $9.10 net each.

PRINTED IN GREAT BRITAIN BY W. LEWIS, M.A., AT THE CAMBRIDGE UNIVERSITY PRESS